
MARYLAND
AGRICULTURAL
EXPERIMENT STATION
1888

FOURTH
ANNUAL REPORT
OF THE
MARYLAND AGRICULTURAL EXPERIMENT STATION,
AT THE
AGRICULTURAL COLLEGE,
COLLEGE PARK,
PRINCE GEORGE'S CO., MARYLAND.

1891.

ANNAPOLIS:
C. H. BAUGHMAN & CO.,
STATE PRINTERS.
1892.

ORGANIZATION

OF THE

Maryland Agricultural Experiment Station.

CORPORATION:

The BOARD OF TRUSTEES of the MARYLAND AGRICULTURAL COLLEGE.

Agricultural (Station) Committee of the Board of Trustees:

Ex-officio, Hon. E. E. Jackson, Governor, *President of the Board.*
Messrs. Goldsborough, Seibert, Silver, Brattan and Biedler.

OFFICERS AND STAFF:

Henry E. Alvord, C. E., *Director.*
Harry J. Patterson, B. S., *Chemist.*
Albert I. Hayward, B. S., *Agriculturist.*
Thos. L. Brunk, B. S., *Horticulturist.*
Milton Whitney, M. Sc., *Physicist.*
Ernest H. Brinkley, *Machinist.*
David B. Perry, *Stenographer.*
Jos. R. Owens, M. D., *Treasurer.*

LOCATION.

On the Estate of the Maryland Agricultural College, in Prince George's County, eight miles north from the City of Washington.

Railroad Station, for Passengers and Freight: College Station, Md. (On the Baltimore & Ohio R. R.)

P. O.—College Park, Prince George's Co., Maryland.

Telegraph Address.—College, Md. (Western Union Tel. Co.)

Express Office.—College Station, Md. (United States Express Co.)

☞ *Address, in all cases—*

MD. AGR'L EXPERIMENT STATION.

FOURTH ANNUAL REPORT

OF THE

MARYLAND AGRICULTURAL EXPERIMENT STATION,

FOR THE YEAR 1891.

REPORT OF THE DIRECTOR.

The past year has been the busiest one which the Station has had. More work has been done, and of greater variety, than heretofore. In order to give "a full and detailed report of its operations," as required by law, the printed record must be extended beyond the limits of previous years. As time passes the facilities for work become more complete. The land is brought into a more satisfactory condition; trees grow and perennial plants become established; buildings are extended; appliances are increased, and the equipment generally is improved. Thus far, we have been able each year, to expend less time and money upon preparation, and more for labor and the current expenses of experimentation, than the year before. The time will soon come when, with our fixed income, it will be impossible to materially increase the quantity or the variety of the work; the question will then be, how, in what directions, and upon what subjects, the resources at our command can be best applied, year by year.

THE SEASON:—As heretofore, it is necessary to first report upon the weather, in order that the climatic conditions may be understood, which have applied to the field-work of the Station, during the year.

The season of 1891 has here differed from the normal mainly in its "precipitation" or rainfall. The quantity and distribution of the rainfall is the prime factor in the climatology of this latitude, as regards the agricultural interests of the year. The figures following compare the past season, in this respect, with the two next preceding, and show it to have been a year of excessive rainfall.

Years:	1891.	1890.	1889.	Normal,
Rainfall in Inches:	50.55	36.29	59.59	44.+
Number of Rainy Days:	128.	151.	135.	?

By comparing the depth of rainfall with the number of rainy days, it is apparent that the year 1890 was one of less than an average quan-

tity of rain well distributed, while in 1891, as well as in 1889, there was excessive rainfall concentrated in comparatively few days, or heavy rains. With forty per cent. more rainfall than the year before, and all of this excess during the first seven months of the year, it will be readily understood that field-work was much interrupted and retarded. Yet May was a dry month, too dry for grass, cutting short the hay crop, but favorable for grain. The late summer and autumn months, on the other hand, were rather dry and fair, without being too warm, and exceptionally fine for ripening corn and for most farm work. The general facts, as recorded in different parts of the State, are shown by the following table of yearly averages:

PLACE OF RECORD.	TEMPERATURE.		RAINFALL, INCLUDING SNOW.		
	Normal Mean.	Mean of 1891.	Normal in Inches.	In 1891, Inches.	Rainy Days. No of in 1891.
College Park, Md.......	54.-?	54.31	44.—?	50.55	128.
Washington, D. C......	54.8	55.35	44.44	52.54	138.
Baltimore, Md.........	53.1	55.60	44.34	54.21	143.
Cumberland, Md.......	51.8	53.35	33.19	46.25	96.
Wicomico Co., Md......	...	55.7	....	56.17	....

Detailed records of the observations at this Station (recorded as College Park) are given in tables appended to this report. The other records, which afford an interesting comparison, have been courteously supplied by the Weather Bureau at Washington and the Maryland State Weather Service.

It appears that at all points reported, the mean or average temperature for the year was rather lower than for 1890. This applied to every month in the year except April, which was warmer than usual, and December, which averaged 9 degrees warmer than the year before, although cooler by 2 degrees than the same month

in 1889. In other words, the Summer was cool and the Winter was mild. The mean temperature for 1891 at this Station was 1½ degrees lower than the year before. As noted last year, the mean temperature at the Station seems to range about one degree less than at the cities of Baltimore and Washington. In Wicomico county the record closely agrees with Baltimore, and at Cumberland, as usual, it was considerably cooler.

In the rainfall record some of the same features are seen as last year. We had less rainfall by two to four inches, and fewer rainy days by ten to fifteen, than in the cities on either side of us. The rainfall of the year, within this State, appears to have increased from West to East. Of the places above reported, Cumberland had the least this year, instead of the most, as in 1890. But after all, as is elsewhere shown in this Report, the quantity of rain which falls upon the soil, and even its distribution, concerns us far less, agriculturally, than the question of how it moves after entering the soil, and what we can do to control this movement and measurably regulate the supply of moisture for our crops.

Co-operation:—Less has been done than in years previous, in co-operative work with other Stations, and less than is believed to be economical and judicious. For the best results from this national system of Experiment Stations, there should be more co-operation and co-ordination in the work of the Stations in the several States, and this should be required by law, to a reasonable extent, if it does not come about naturally and voluntarily. In the work of this Station, within the State, co-operative effort has been necessary, and willing and efficient helpers have been found, as later mentioned in appropriate places.

Scientific Expedition to Southern Maryland:—Several lines of proposed work made a preliminary visit to Southern Maryland expedient, early in the year. A party was organized, including representatives of the United States Topographical and Geological Surveys, the Johns Hopkins University and this Station, with several visiting scientists from other States. Upon application, the Board of Public Works considerately granted the use of the Steamer Gov'r Thomas, and an attending schooner, from the State Fishery Force, after the close of the season of police patrol, and thus provided suitable transportation and quarters. The party paid for all labor and

provisions incident to the trip. The expedition took place in May, starting from Baltimore and ending at Washington. The Western shore of Chesapeake Bay was closely examined, as well as the Patuxent river, as far as navigable, and the Maryland side of the Potomac; frequent excursions were made inland, as far as circumstances permitted. The subjects studied by different members of the party included the topography, geology and soils of the region, its vegetation and staple crops, the marl deposits and the oyster beds. Much of the work of this Station for the year, connected with tobacco, marls and soil studies, was laid out at this time.

The expedition was pronounced a success by all concerned, and it suggests a way in which portions of the State Fishery Force can be profitably used at times, when not otherwise needed, to assist in promoting the material welfare of the State, and without additional public expense.

THE JOHNS HOPKINS UNIVERSITY:—This great university has constantly shown its earnest wish to co-operate with the Station in any work tending to develop the natural resources of the State. This is evidenced by the share it has taken in the expedition above mentioned, and in the State Weather Service, the Map of Maryland and the Soil Investigations, as briefly acknowledged in the Report of the Maryland Agricultural College for 1891. President Gilman has not only responded cordially to every suggestion made, and been effectively supported by the Board of Trustees,—but offers of assistance have been made far beyond what could have been asked. Some of the important work of the Station would have been impossible, at least for some years to come, but for this substantial aid. This has been shown especially in connection with the Soil Investigations conducted by Professor Whitney. In arranging for this work, it became evident that its success depended upon being so situated, at the outset, as to have available fully equipped laboratories and libraries, and the personal help of eminent investigators, in solving such purely scientific problems in chemistry, geology and physics, as might arise in the progress of the investigations. All these facilities were freely offered by the University, and it was manifestly expedient, if not necessary, to locate the work in Baltimore. Rooms were at first placed at our disposal in the geological building of the University, but the work soon outgrew those limited accommodations, and the

University Trustees then gave the use of the Hopkins Mansion at Clifton, on the Harford Road, and all desired privileges upon the entire estate. This comprises over four hundred acres of park, woodland, arable fields, gardens, orchards and green-houses, all well kept and offering ample facilities for the observation and study of soils, under varied conditions, with and without crops. The mansion furnishes admirable accommodations for laboratories, office and quarters for the workers, thus concentrating the work of this division of the Station. Clifton is within three miles of the centre of the city, directly upon a horse-railway line, and thus having easy communication with all parts of the State. This generous action on the part of the University, as well as the lively interest and cordial support evinced by all its officers, calls for especial praise and appreciative acknowledgment.

Soil Investigations:—In the last Annual Report of the Station, it was stated that an effort was about to be made to institute a systematic study of the agricultural soils of Maryland, with a view to their classification, description, defining the boundaries of typical formations and explaining local variations. The Station was soon after fortunate in securing the services of a competent person to undertake the work; this was the first essential step. The reasons for locating this branch of our Station work at Baltimore, and the particularly favorable auspices under which it has been there begun, have been already described. The preliminary report upon the first year's progress in these investigations, will be found at page 249, and to it attention is particularly invited.

A knowledge of the soil we cultivate, with its characteristics, changes, condition and capabilities, veritably lies at the foundation of all agricultural progress. It is not rational to grope about blindly and try hap-hazard experiments, with a view to improving a worn and apparently impoverished soil, without knowing something more than the single fact that it is unproductive. The true causes of its condition, or deterioration, and accurate information as to the difference between it and a soil satisfactorily productive, seem essential to intelligent and successful treatment. But in this all-important field, science has thus far done little for the practical benefit of the farmer. There have been few workers anywhere in this line, and especially in America. It is, however, too important a branch of agricultural research to be longer neglected. This Station takes pride in being the

first to establish a division and assign a staff-officer exclusively to soil investigations, and in commencing the work, with such strong allies and under such auspicious circumstances.

It will be seen from the following report, that the subject has been approached upon a line which is in the main new, at least for this country. The present presentation of the work must be understood as preliminary and subject to the modifications and changes which may result from further investigations. But the work already accomplished has developed indications which, if verified by subsequent research, will establish truths of great importance and far-reaching in the application of science to the treatment and cultivation of the soil. As thus presented, the subject cannot fail to command the attention of students of agriculture,—and will probably call forth criticism. The latter is desired and invited. The officers of this Station wish to receive the opinions of fellow-workers everywhere, as to this soil investigation as thus far reported, and their views and suggestions as to its further prosecution.

Professor Whitney's report is also commended to the attention of every practical farmer and owner of agricultural land who may have the opportunity to read it. New things develop new ideas and necessitate new names and phrases. If parts of this report are found to require not only careful reading, but actual study, to be well understood, the extra mental effort will do no harm, and it is believed it will be well repaid. It must be remembered that this is preliminary work. Methods of investigation have to be first studied and justified. The first steps have been recorded as concisely and clearly as possible, although necessarily dealing with subjects and using terms which will be unfamiliar to many readers. The soil samples which are brought into use in these early stages of the work, are limited and represent only part of the State; this could not be otherwise. But as the work proceeds and later reports are made, the subject will become more familiar,—its processes and conclusions will be plainer. As time passes the investigation will embrace wider areas and more local questions,—and the application of its results will become of greater individual interest and value.

It is gratifying to know that this soil investigation was planned and is being conducted by a native of Maryland, who spent his boyhood in that section of the State which contributes the first material to the work, and was later a student of science in the University which is now so generously contributing to the success of his labors.

Tobacco Experiments:—In accordance with the intention stated in the last annual report, tobacco experiments have formed one of the leading features of the Station work, during the past season. This work has been divided into three branches:—1,—comparison of varieties of tobacco; 2,—the effects of different fertilizers on the same kinds of tobacco, tried on different soils; 3,—the results of varied and improved methods of curing.

Expert assistants were secured for different parts of the work, in this State, and from Virginia and North Carolina. The Station also received the cordial and efficient co-operation, throughout the season, of the Leaf Tobacco Association of Baltimore, and of several enterprising planters in different counties. There were some casualties and disappointments, but, as a whole, the experiments of the year were favorably conducted and concluded, except the final chemical parts. There is much of this laboratory work remaining and it is necessarily slow business. Upon its results and the commercial tests with the cured tobacco, rest the conclusions and deductions of the season. It is thought best to defer the detailed description and full report upon the work, until the chemical portion is completed. All can then be published as a bulletin. Therefore, only a brief statement of what has been done, will now be given.

Varieties:—Plants from pure seed of thirteen improved varieties, were grown under like conditions, here at the Station, and with reasonable success. Some loss was experienced from what is known as "frenching," which presents a subject requiring special investigation. The several varieties were also grown on plots of land differently manured or fertilized. The improved varieties mainly tried in other counties were the Orinoko and Saffrano. It is believed that both can be advantageously introduced and used, under certain favorable conditions. While detailed conclusions await the results of marketing the crop, it seems evident that the use of pure seed, carefully selected as to variety and adaptability, is by no means to be rejected. This is one of the ways in which the tobacco product of the State is to be improved. Although deterioration of introduced varieties may be found rapid, upon Maryland soil, this difficulty may be easily overcome by procuring the seed from a distance every year. If, as seems probable, the improvement in crop warrants so doing, an annual supply of new and pure seed is a small item.

Field Experiments:—The Leaf Tobacco Association of Baltimore recommended to us desirable locations in six counties, at which to conduct field trials, with liberal and progressive men to assist in the work. As a result, experimental acres were selected in five counties, carefully laid out, prepared and each divided into ten plots by the Station agents. Upon these plots different fertilizers were applied. Circumstances prevented the location of such an acre this year in St. Mary's, but it is hoped to include that county in the future. Samples of cured plants, from the several plots of these acres, are now passing through the laboratory. The points which it is hoped to develop are economy of production and effect upon quality and market value by the different methods of special feeding.

Curing:—The Association mentioned assisted the Station by a liberal cash contribution in bringing one of the patent Modern Tobacco Barns from North Carolina and setting it up for trial, for the present, in Calvert County. Mr. J. Benson Posey, upon whose place it is located, near Mt. Harmony, did his full share in connection with this trial. Flue-curing houses, with and without some of the peculiarities of the Snow process, were fitted up by the Station, or under its supervision, in Prince George's, Calvert and Charles counties. In all these, tobacco was cured by our expert helpers, of the standard Maryland type and of a few improved varieties. Samples of the same tobacco were cured, for comparison, by methods more common in the State. The chemical and commercial comparisons of all these, also remain to be made. The experience of the season shows that these improved methods of curing must be adapted to the conditions peculiar to this State. But having made these adaptations and acquired practical experience in managing the houses, it will be easy to demonstrate the economy of certain forms of improved curing; and it now appears that this will apply to the ordinary type of Maryland tobacco. A large part of the tobacco crop of this State is woefully neglected, and much actually ruined, every year, after being well and successfully grown. It is to improved methods in curing and marketing the crop that attention should be mainly given, for the relief of Maryland planters, and for raising the standard of Maryland tobacco.

Marls and Limestones:—Closely allied with our soil studies is the examination of the marls, limestones and other formations of agricultural interest, in various parts of the State. These will be

ultimately brought into the geological and soil mapping and classification, but for the present most of the work done upon them is of a chemical nature. The numerous samples obtained and examined during the year are described in the appended report of the Station Chemist. In that connection some general information is introduced which may be found of practical value. It is interesting to note that year after year our efforts are rewarded by finding deposits of marl richer in plant food and agricultural value. The list published in this report contains the analyses of some marl samples from large deposits in Charles county, which compare favorably in content of potash and phosphoric acid, with the famous "green sands" of New Jersey, which have added so largely to the agricultural wealth of that State.

Feeding Experiments:—The Station now has pretty good facilities for experimental feeding, and it is proposed to do more or less of this annually. During the past year feeding experiments have been completed with swine, milch cows and beef cattle. The record of the pig feeding, which included the work of two years, and had reference particularly to the summer treatment of growing shotes, was issued as Bulletin No. 12, for March, 1891. The trial with milch cows had reference to changes in the composition of milk produced, as the effect of special feeding; the results were negative and unsatisfactory in character, and the trial should be repeated before the record is published. In the experiment with beef cattle, four very fine Hereford steers were the subjects, and the operations extended over ten weeks, involving much care and labor. The questions at issue were of a chemical and physiological nature, relating to the digestibility of corn silage and corn stover,—and the effects of acid in the food. The record is, therefore, embodied in the following report of the Station Chemist, and constitutes the greater portion thereof. The simpler matters of the relations of the food and feeding to gain in weight, or beef production, are reserved for use in a future bulletin, with other records of a similar character. The report upon the chemical aspects of this work deals with some of the fine points in the economy of feeding, or what may be called scientific feeding. The effort has been to make the record complete, and although this results in its being elaborate and somewhat intricate, with more figures and tables than are popularly approved, the work is so directly

practical in its bearings that a careful perusal of the report is recommended to all interested in this line of farming operations.

Dairy Work:—The dairy interests of the State appear to be on the increase, especially in the form of creameries. Much dissatisfaction has been found to exist among the "patrons" of creameries, both proprietary and co-operative, over the now antiquated and manifestly unjust system of paying the same price per 100 lbs. for all milk, regardless of its quality. Although still practiced, as a rule, by the creameries in this State, this system has been generally rejected in the most progressive dairy regions in the country, and methods have been adopted for testing every lot of milk purchased or received at the creamery, and paying for it according to a fixed standard of quality. Interest, therefore, attaches to these new methods of milk-testing, or "fat tests," and the subject therefore, receives some attention in the Chemist's report.* A brief record is added, of a trial to determine the effect on the results of fat-testing, of delay in handling the milk samples taken for that purpose.

Agriculturist's Report:—The report of the Station Agriculturist, which will be found in later pages, contains the record of those portions of the work of the year, which have heretofore been presented under this head. Among these are Silos and Silage (or ensilage); Corn experiments; Variety tests with Oats and Wheat; the season's record on Grasses, Clovers and other Forage Plants; the Rotation Plots record and Potato experiments. These subjects will all be of more or less interest to different readers, who are referred to the report for all details and for such deductions or inferences as are justified by the record. The effects of different modes of cultivating fodder-corn, as well as of planting the same, are worthy of note; this year's record certainly justifies the advice to put the rows pretty close, seed thinly and cultivate very shallow, barely stirring the surface. In the potato work, although poor crops again prove the soil of this Station unsuited to this tuber, the same general conclusion is reached, in favor of planting whole potatoes of about egg-size. And again has been demonstrated the decided gain, here at any rate, of getting fresh Northern-grown stock for planting, every year.

*Later:—It is possible that it may be found necessary to omit this subject from this report and issue it later as a bulletin.

Horticulturist's Report:—The last report of the Station noted the fact that its horticultural work was being extended and given greater variety. The progress made in this direction will be seen from the report of the Station Horticulturist, for the past year, which is one of the appended papers. This deals with numerous subjects of interest to the gardener and fruit-grower, which need not be mentioned in detail, but special attention may be called to the section on Spraying with various solutions and mixtures, for preventing losses from plant diseases and injurious insects,—and the utensils for this work. The annual comparison of Strawberries, for 1891, including more varieties and more detailed work than the year before, was made the subject of the June Bulletin, No. 13; circumstances have delayed the distribution of this bulletin. An interesting series of experiments in Pruning, Root-pruning and Planting of trees and vines, is nearly completed and will be made the subject of a future bulletin.

Station Improvements and Needs:—The building allowance for the current fiscal year has been mainly used in adding a wing to the stable, which provides sheds and storage room greatly needed, with tool-rooms, seed-room, work-shop, etc. This has been finished and painted. Desirable additions have been made to the scientific instruments, chemical apparatus and library.

During the coming year, the means available should be applied to fitting up the museum and some other interior improvements needed in the office building and the outbuildings. Yet it may be found expedient to defer these, and instead, to build one or more tobacco-curing houses.

As soon as it becomes possible, quarters should be built for one or two of the families of permanent employees, also a small green-house and a building specially adapted to the work of the horticultural department, including cellars or other storage for fruit and vegetables.

The annual allowence is so small, for such purposes, that these needs of the Station can be but slowly supplied.

Exhibitions and Meetings:—The policy has been continued of participating as often as possible in appropriate agricultural exhibitions and meetings held in different parts of the State. Several hundred dollars are expended in this way annually, and the Station officers give as much time to this branch of the work as can be spared

from home duties. During the Autumn of 1891, exhibits were made by the Station in the counties of Baltimore, Frederick, Montgomery, Talbot and Washington; and by special authority of the Trustees, an additional exhibit was made at the Southern Inter-State Exposition at Raleigh, North Carolina. Representatives of this Station have attended and participated in public meetings held during the year in thirteen different counties in the State.

VISITORS AND CORRESPONDENCE:—These two methods of intercourse with those who are interested in the work of the Station, are encouraged as much as possible, and both are increasing. No opportunity is lost to make it known that visitors, singly or in parties, with or without previous notice, are always welcome, and that effort will be made to make such visits pleasant and instructive. Those who cannot come are encouraged to write, suggesting and inquiring, and the Station officers give such letters every possible attention. This correspondence now constitutes a large part of the office work, and embraces a great variety of subjects connected with agriculture and horticulture.

PUBLICATIONS:—The following are the publications of the Station for the past year:

The Third Annual Report, dated January, 1891, pages 75 to 146.

Bulletin No. 12, March,—Pig Feeding; pp. 147 to 160.

Bulletin No. 13, June,—Strawberries; pp. 161 to 200.

Bulletin No. 14, September,—Wheat; pp. 201 to 216.

Bulletin No. 15, December,—Insects Injurious to Wheat; pp. 217-232.

Special Bulletin "D.," February,—Analyses of Commercial Fertilizers.

Special Bulletin "E.," August,—Ditto.

These bulletins and reports have been mainly distributed by mail, although all of them have not yet been sent out.

Attention is called to the comments in the last Station Report upon the nature, publication and distribution of the documents prepared here, and the advantages which would result to have all this printing done by the State Printer.

THE STATION STAFF:—The only change in the scientific staff of the Station during the year, has been the addition of Prof. Milton Whitney as Physicist. He has been for some years connected with the Experiment Stations of North Carolina and South Carolina, being vice-director of the latter. The best evidence of the industry and efficiency of all the members of the Station staff is in the several division reports, which will be found in the following pages.

The acknowledgments of all the workers at our Station are due to the Board of Trustees, and especially to its Agricultural Committee, for continued confidence and support, and to the public, for patient interest and friendly encouragement.

HENRY E. ALVORD, *Director.*

MARYLAND AGRICULTURAL EXPERIMENT STATION.

THE ANNUAL FINANCIAL REPORT, 1890–91.

The Maryland Agricultural Experiment Station in account with the United States Appropriation.

1891.				DR.
June 30.	To Receipts from the Treasurer of the United States in four payments, per appropriation for the year ending June 30, 1891, under Act of Congress, approved March 2, 1887,—see Ledger page 306		$15,000 00	
				$15,000 00

1891.	CREDITS.	LEDGER PAGE.	AMT.	
June 30.	By Salaries	206	$6,795 00	
"	Labor	220	2,551 23	
"	Supplies	232	1,692 08	
"	Freight and Expressage	242	209 25	
"	Postage and Stationery	246	134 93	
"	Printing and Office Expenses	250	951 65	
"	Library	256	266 80	
"	Tools and Apparatus	258	369 75	
"	Fencing and Drainage	284	168 00	
"	Incidental Expenses	293	79 64	
"	Exhibition and Meetings	311	239 68	
"	Feeding Experiments	317	190 98	
"	Travel and Board Meetings	321	317 37	
"	Soil Examinations	331	229 48	
"	Scientific Instruments	264	56 00	
"	Building and Repairs	279	748 34	
				$15,000 00

I hereby certify that the foregoing statement is a true copy from the books of account of the said Experiment Station.

(Signed:) Jos. R. Owens, *Treasurer.*

Note:—Certificate of Auditors appended to original, forwarded to the Secretary of the Treasury, Washington, D. C.

REPORT OF THE PHYSICIST.

By Prof. Milton Whitney.

SOIL INVESTIGATIONS.

Introduction.

It is proposed at this time to give a brief account of the soil investigations carried on by the Station and attempt to point out the application of the results and conclusions to the explanation and solution of problems in practical agriculture.

We are glad to report that the U. S. Government has taken up this work, and, through the Weather Bureau of the Department of Agriculture, has placed a sum of money at our disposal to enable us to complete some work on hand in order to prepare a full report or monograph, to be ready for publication by next July. In view of the fact that the report to be issued by the Government will of necessity be much fuller and more exhaustive than this can be, and will contain a detailed description of the methods, formulae and data upon which our lines of reasoning are based, we will introduce into this report only such statistical and other data as will make the narrative complete—referring all who wish to follow the subject more closely and in further detail to the Government report.

It has taken six years of constant application, observation and study, in the field, plant house and laboratory, to gain a clear idea of the nature and structure of the soil in its relation to meteorology and agriculture. When, in the fall of 1890, the work was commenced here in its application to the soils of Maryland, several fundamental principles of soil physics still remained to be worked out. This required the use of very expensive apparatus, only to be found in a well-equipped physical laboratory. It was essential, also, that the work be based upon the most thorough geological data to show the area and distribution of the different soil formations. There was no reliable geological map of the State, and the Director of the U. S. Geological Survey stated that the Professors of Geology of the Johns Hopkins University had all the available data, and were themselves

working out in more detail the geology of Maryland, and advised a co-operation with them in this soil work.

The work of this division of the Experiment Station on the investigation of soils was, therefore, located at the Johns Hopkins University. By permission of the Trustees of the University the work was moved in June to their large estate of Clifton, on the Harford Road, where it is at present being carried on. The reasons for this and our relations with the University are more fully set forth in the Director's report.

The President of the University and the Professors in the Departments of Chemistry, Geology and Physics have shown, from the first, an interest in the work and a cordial spirit of co-operation, with a desire to have us make a practical application of their work and information.

Argument.

It takes really very little experience for one to judge at a glance whether a soil is suited to grass or wheat or tobacco or watermelons, and he has but to turn up a small handfull of earth to see if the soil is in good condition, as regards moisture, for the growing crops. And yet, agricultural chemists have worked over this problem for years, arguing points from minute differences in chemical composition of the soils or plants, which their most refined methods make none too sure, overlooking the fact that the farmer can tell from the *appearance* whether a soil is in "good heart" and what it is best fitted to grow. The farmer cannot see these minute differences in chemical composition. He judges from the general appearance of the land, the physical structure of the soil.

Those of us who are engaged in agricultural investigations, even in soil studies, are not as far advanced as the farmer in our knowledge of the soil, nor will we be until we can understand and explain these visible signs upon which he bases his judgment. He has kept up with our work on the chemical composition of soils and has applied it and made it his own. But he goes further than we have gone, for he can tell, as no chemical means will enable us to judge, whether the land is in good condition, is fertile, has body and will hold manures, is strong or will shortly run out, is dry and leachy or retentive of moisture. He can tell what class of plants it will best produce. In this lies the key to all soil investigations. Chemical analysis has its

part to play, but we have yet to get the key to the interpretation of its results. And this key is to be found in the study of the physical structure of the soil and the physical relation to meteorology and to plant growth. Meteorology has not done, and is not doing, its best good for agriculture. While we admit it is very important to have the rainfall data furnished by the Weather Bureau, still, as the rain does not benefit the crops until it enters the soil, it is very essential that the rainfall be studied below, as well as above, the surface of the ground.

Crop production is not directly limited by the amount of rainfall, but by the moisture in the soil. Six inches of rainfall a month may mean a good season, or, with this same amount differently distributed throughout the month, the crops may be injured by excessive wet or by prolonged drought. Changing seasons of wet or dry, hot or cold, have far more effect on the crops than any combination of manures.

There is a certain type of land in this State, in a certain geological formation, which is left out in pine barrens as it is too poor to put under cultivation; another type, in a different geological formatian, is well suited to melons and garden truck; still other types, to tobacco, wheat and grass. This is not a matter of mere plant food. No addition of any amount or any combination of available plant food will at once enable a good wheat crop to be produced on the soil of the pine barrens, or on the light truck lands. It is a matter of available water rather than of available plant food, and if after some years the light land is brought up to produce good yields of wheat, the whole appearance and structure of the soil will be found to have changed, and with it, the relation of the soil to the movement of water—*to the movement of the rainfall after it enters the soil.*

And so in the deterioration of land, in the deterioration of our tobacco and wheat lands. It is not due to loss of plant food so much as to the causes which change the whole appearance of the soil to the eye—a change of the physical structure of the soil, a change in the relation of the soil to the movement or circulation of water.

Our work, then, is on the physical structure of the soil and its relation to the circulation of water—the movement of the rainfall after it enters the soil, and the physical effect of fertilizers and manures thereon, as related to crop production.

Summary of the Results.

This report will treat first of the underlying principles governing the circulation of water in the soil, then of the different soil types found in the State, of their structure and relation to the circulation of water, leading up to the application of these principles in a discussion of the improvement of lands. A summary will be given here, outlining the body of the report, so that it may be followed more easily.

I. The circulation of water in the soil.

a. Due to gravity or the weight of water acting with a constant force to pull the water downward, *and also*, to surface tension or the contracting power of the free surface of water, (water-air surface,) which tends to move the water either up or down or in any direction, according to circumstances.

b. The ordinary manures and fertilizing materials change the surface tension or pulling power of water.

II. The effect of fertilizers on the texture of the soil.

a. There is a large amount of space between the grains in all soils in which water may be held. The rate of movement of the water will depend: 1. Upon how much space there is. 2. Upon how this is divided up, *i. e.* upon how many grains there are per unit volume of soil. 3. Upon the arrangement of the grains of sand and clay.

b. Flocculation—a phenomenon of great importance in agriculture—changing the arrangement of the grains and consequently the texture of the soil.

III. The volume of empty space in soils.

IV. The relation of geology to agriculture.

V. Soil types.

a. Reasons for establishing soil types.

b. The very evident difference in texture is the probable cause of the difference in relation to plant growth and to local distribution of crops.

c. Soil types in Maryland and the samples from which they are made.

VI. Mechanical analysis of the type soils.

VII. Approximate number of grains per gram of soil.

VIII. Approximate extent of surface area per cubic foot of soil.

IX. The circulation of water in these type soils.

a. The relative rate of circulation of water in soils short of saturation is very different in these type soils and probably explains the difference in relation to crop production.

b. The relative rate of circulation of water in these soils when fully saturated.

c. The influence of the total volume of space.

d. The rate of circulation of water is relatively faster in light sandy lands, when far short of saturation, than in heavier clay lands, but it may be far slower in these same light lands when fully saturated, owing to the less amount of space in the soil.

X. The improvement of soils.

a. In soils having as much clay as the type requires, the grains of clay may be rearranged by causing flocculation, or the reverse, by the use of ordinary fertilizing materials.

b. In soils having less clay than the type: 1. The grains may still be rearranged, or, 2. organic matter may be precipitated from solution within the soil, in light, flocculent masses, with lime, acid phosphate, or the proper mineral manures, or constituent of the soil itself, and so fill up the spaces and retard the rate of circulation of the water.

I. The Circulation of Water in the Soil.

The motive power, which causes water to move from place to place within the soil, consists of two forces: gravity, or the weight of the water itself, and surface tension. Gravity tends to pull the water downward, and acts with a constant force per unit mass of water. Surface tension, or the contracting power of any exposed water-surface, may move the water in any direction within the soil, according to circumstances. It may act, therefore, *with* gravity to pull the water down, or *against* gravity to pull it up. This has an important practical bearing on the movement of water in sandy lands, as we shall show in speaking of the application of these principles to our type soils.

The force of gravity need not be further considered here.

Surface tension is the tendency which any exposed surface has to contract to the smallest possible area, consistent with the weight of the substance. If a mass of water is divided, or cleft in two, leaving two surfaces exposed to the air, the particles of water on either surface, which were before in the interior of the mass and attracted from all sides by like particles of water, have now water particles on only one side to attract them, with only a few air particles, comparatively very far apart, on the other side, where formerly was a compact mass of water. All the surface particles of water will therefore be pulled from within the mass of water, and the surface will tend to contract as much as possible, leaving exposed the smallest number of surface particles, and causing a continual strain or *surface tension*. On any exposed water-surface, there is always this strain or tension, ready to contract the surface, when it may.

It is a constant, definite force per foot of surface, for any substance at a given temperature. In the case of liquids and solutions, in which we are most interested, it varies with the nature of the liquid and the substance in solution.

This is *surface tension;* and we have it in the soil as a strain or tension along the free surface of water within the soil, which tends to contract the surface and so move the water from one place to another as it is needed.

There is, on the average, about 50 per cent. by volume of space within the soil which contains no solid matter, but only air and water. This we shall call *empty space.* In a cubic foot of soil there is about half a cubic foot of empty space, but this is so divided up by the very large number of soil grains that the spaces between the grains are extremely small.

When a soil is only slightly moist the water clings to the soil grains in a thin film. It is like a soap bubble with a grain of sand or clay inside, instead of being filled with air. Where the grains come together the films are united into a continuous film of water throughout the soil, having one surface against the soil grains and the other exposed to the air in the soil. As the soil grains are surrounded by this elastic film, the tension on the exposed surface of the water will support a considerable weight, for the soil grains, thus enveloped, are extremely small and have many points of contact around which the film is thicker and is held with greater force.

If more water enters the soil the film thickens, and there is less exposed water-surface. If the empty space is completely filled with water there will be none of this exposed water-surface, and therefore, no surface tension. Gravity alone will act and with its greatest force. If the soil is nearly dry, there will be a great deal of this exposed water-surface, a great amount of surface tension, and with so little water present, gravity will have its least effect.

The grains in a cubic foot of soil have, on the average, no less than 50,000 square feet of surface area. There is less, of course, in a light sandy soil, and more than this in a clay soil. If there is only a very small amount of water in the soil the film of water around the grains will be very thin, and there will be nearly as much exposed water-surface as the surface area of the grains themselves. If a cubic foot of soil, thus slightly moistened, and having this large extent of exposed water-surface, be brought in contact with a body of soil fully saturated with water, in which there is none of this water-surface, the water-surface in the drier soil will contract, the film of water around the grains will thicken and water will be drawn from the wet into the dry soil, whether it be to move it up or down, until, neglecting gravity or the weight of water itself, there is the same amount of water in the one cubic foot of soil as in the other. When equilibrium is established there will be the same extent of exposed water-surface in these two bodies of soils.

When water is removed from a soil by evaporation or by plants, the area of this exposed water-surface is increased, and the tension tends to contract the surface and pull more water to the spot.

When rain falls on rather a dry soil, the area of the exposed water-surface in the soil is diminished, and the greater extent of water-surface below contracts and acts, with gravity, to pull the water down.

By numerous careful and verified experiments, we have found that fertilizers change this surface tension and modify the contracting power of the free surface of water to a remarkable degree, and so modify thepower which moves water from place to place in the soil.

The following table gives the surface tension of a solution in water of several of the ordinary fertilizing materials. This list is not complete, and the solutions used were of any convenient strength. The results are preliminary to give material for more thorough and detailed investigation. The surface tension is expressed in gram-meters

per square meter, that is, on a square meter (or yard) of liquid surface there is sufficient energy to raise so many grams to the height of one meter (yard.)

TABLE 1:—THE SURFACE TENSION OF VARIOUS SOLUTIONS.

(*Gram-meters per square meter.*)

SOLUTION OF	SP. GR.	*	MEAN.	HIGHEST.	LOWEST.
Salt	1.070	6	7.975	8.126	7.796
Kainit	1.053	6	7.900	7.993	7.805
Lime	1.002	4	7.696	7.750	7.674
Water	1.000	18	7.668	7.923	7.506
Acid Phos	1.005	4	7.656	7.800	7.563
Plaster	1.000	9	7.638	7.730	7.572
Soil extract	1.000	5	7.089	7.166	6.969
Ammonia	0.960	6	6.869	6.950	6.826
Urine	1.026	10	6.615	6.740	6.471

* Number of measurements from which the mean is taken.

WULLNER GIVES THE FOLLOWING:*

	SP. GR.	TENSION.
Water	1.000	7.666
Sulphuric acid	1.849	6.333
" "	1.522	7.610
" "	1.127	7.556
Hydrochloric acid	1.153	7.149
Nitric acid	1.500	4.275
" "	1.270	6.768
" "	1.117	7.098
Salt	1.200	8.400
Nitrate of potash	1.137	7.276

*Lehrbuch der Experimental Physik, Vol. I., p. 341.

The soil extract was made by shaking up a little soil with just sufficient water to cover it; the water was afterwards filtered off and used for the determination. It will be seen from the table that this contact with the soil reduced the surface tension of water very considerably. There is little doubt that the surface tension of soil moisture is very low, much lower than that of pure water. Salt and kainit, on the other hand, increase the surface tension of water very considerably and raise it far above that of the soil extract. This probably explains the fact, which has been often commented on, that an application of salt or kainit tends to keep the soil more moist. This has often been remarked in connection with the application to a clover sod. By increasing the surface tension of the soil moisture they increase the power the soil has of drawing water up from below in a dry season.

Ammonia and urine lowered the surface tension of water considerably below that of the soil extract, and far below that of pure water. This, probably, also explains a matter of common observation, that the injudicious use of excessive quantities of organic matter is liable to "burn out" a soil in a dry season, because by reducing the surface tension, water can less readily be drawn up from below.

This opens up a field of investigation on the determination of the surface tension of the moisture in various soils, and a more extensive and more systematic study of the effect of various fertilizing materials on the surface tension of water and soil extract, and it opens up a wide field in its application to practical agriculture and the use of manures and fertilizers.

This effect of fertilizing materials in changing the surface tension of a liquid, and thereby changing the force or power which moves water from place to place in the soil, is only a first effect, as the continued use of these fertilizing materials may change the texture of the soil itself and the relation of the soil to the circulation of water.

II. The Effect of Fertilizers on the Texture of the Soil.

Surface tension may be expressed in another way. The *potential* of a single water particle is the force which would be required to pull it away from the surrounding water particles and remove it beyond their sphere of attraction. For simplicity, it may be described as the total force of attraction between a single particle and all other particles which surround it. With this definition it will be seen that

the potential of a particle on an exposed surface of water is only one-half of the potential in the interior of the mass, as half of the particles which formerly surrounded and attracted it were removed when the other exposed surface of water was separated from it. A particle on an exposed surface of water, being under a low potential, will therefore tend to move in towards the center of the mass where the potential, i. e., the total attraction, is greater, and the surface will tend to contract so as to leave the fewest possible number of particles on the surface.

If instead of air there is a solid substance in contact with the water the potential will be greater than on an exposed surface of the liquid, for the much greater number of solid particles will have a greater attraction for the water particle than the air particles had. They may have so great an attraction that the liquid particle on this surface, separating the solid and liquid, may be under greater potential than prevails in the interior of the liquid mass. Then the surface will tend to expand as much as possible for the particles in the interior of the mass of liquid will try to get out onto the surface. This is the reverse of surface tension. It is surface pressure, which may exist on a surface separating a solid and liquid.

If two small grains of clay, suspended in water, come close together, they may be attracted to each other or not, according to the potential of the water particles on the surface of the clay. If the potential of the surface particle of water is less than of a particle in the interior of the mass of liquid, there will be surface tension and the two grains will not come together because this would enlarge the surface area and increase the number of surface particles in the liquid. If, on the other hand, the potential of the particle on the surface of the liquid is greater than the potential of a particle in the interior of the liquid mass, the surface will tend to enlarge and the grains of clay may come close together and be held there with some force, as their close contact increases the number of surface particles in the liquid around them. This probably explains the phenomenon of flocculation, a phenomenon of great importance in agriculture.

Muddy water may remain turbid for an indefinite time. If a trace of lime or salt be added to the water the grains of clay *flocculate*, that is, they come together in loose, light flocks, like curdled milk, and settle quickly to the bottom, leaving the liquid above them clear. Ammonia and some other substances tend to prevent this and to keep

the grains apart, or to push them apart if flocculation has already taken place. This is similar to the precipitation of some solid matters from solution. When lime is added to a filtered solution of an extract of stable manure, the organic matter is precipitated in similar loose, bulky masses.

It will be remembered that there is, on an average, about 50 per cent. by volume of empty space in the soil. This empty space is divided up by a vast number of grains of sand and clay. If these grains are evenly distributed throughout the soil, so that the separate spaces between the grains are of nearly uniform size, water will move more slowly through the soil than if the grains of clay, through flocculation, adhered closely together and to the larger grains of sand, making some of the spaces larger and others exceedingly small.

We have, then, this principle to work on in the improvement of soils. In a close, tight clay, through which water moves slowly, the continued use of lime may cause flocculation, the grains of clay may move closer together, leaving larger spaces for the water to move through. On the other hand, there are soils in which the clay is held so closely to the grains of sand as to give the soil all the appearance and properties of a sandy soil, although there is as much clay present as in many a distinctively "clay soil."

Again, in a light sandy land, lime may precipitate the organic matter from solution within the soil, in light, bulky masses, which will fill up the spaces and retard the rate of circulation of water.

And so, if judiciously used, lime may be the "best fertilizer" for a light sandy soil or for a heavy clay land. In the one case, there must be sufficient organic matter for the lime to act on or it will injure the soil; in the other case, there is no such need of organic matter in liming a tight clay soil, and too much of it may be decidedly injurious.

We will speak of this more at length when we come to speak of the application of these principles to the improvement of soils.

III. The Volume of Empty Space in Soils.

There is, on the average, about 50 per cent. by volume of empty space in the soil. The amount in the soil proper will vary with the stage and state of cultivation, but the empty space in the undisturbed subsoil will remain fairly constant. The amount of space has not been determined in the soils of Maryland, for the determination

requires that an exact volume of soil be removed from the field, and this takes much time and careful work. This will be made the subject of some future investigation, and for the present our work must be based upon determinations which have been made elsewhere.

The amount of space has been determined in a number of subsoils in South Carolina, in their natural position in the field, taking in a wide range of soil formations. The per cent. by volume of empty space is given in the table following.

TABLE 2:—EMPTY SPACE IN SO. CA. SUBSOILS.

Per Cent. by Volume.

78.	Wedgefield, (sandy land)	41.80
66.	Gourdins	42.82
57.	Sumter	44.10
80.	Lesesne	46.41
57a.	Sumter	47.70
69.	Gourdins, (Mr. Roper)	49.74
64.	Lanes	50.00
74.	Wedgefield, ("Red Hill" formation)	50.03
69a.	Gourdins	50.25
53.	Charlotte, N. C.	52.05
71.	Gourdins, ("Bluff land")	55.40
53a.	Charlotte, N. C.	57.19
76.	Wedgefield, ("gummy land")	58.46
76a.	Wedgefield, ("gummy land")	61.54
42.	Chester, ("pipe clay")	65.12

The first six subsoils, which may be considered essentially sandy, have, on the average, 45.43 per cent. by volume of empty space. The remaining nine subsoils, which are from essentially clay lands, have, on the average, 55.55 per cent, by volume of empty space.

In "How Crops Feed," Johnson gives the weight of a cubic foot of sandy soil as 110 pounds, and of a cubic foot of a clay soil as 75

pounds. This would give about 34 and 55 per cent. by volume of empty space, respectively, in these soils.

It is unfortunate that the term "light soil" has become commonly applied to that which actually weighs a good deal more than an equal bulk of what is called "heavy soil."

In our own work, unless the actual determinations have been made, we have assumed that the subsoil of "light sandy land" has 45 per cent. by volume of empty space, and that of a strong clay land, 55 per cent. If all the space within these soils was filled with water, they would contain 22.41 and 31.55 per cent. *by weight* of water, respectively.

For the empty space in our soil types, to be presently described, we have assigned, as probable, values based on this South Carolina work.

IV. The Relation of Geology to Agriculture.

We shall use in this report certain geological names which may be unfamiliar to many of our readers, and it seems well to insert a section explaining the reason for this and the general relation of geology to agriculture.

We shall show presently that there are well-marked types of soil in this State; some suited to grass and wheat, others to wheat but rather light for grass, others to tobacco, truck, or left out as barren wastes. The texture and general appearance of these soils differ very much so that one can tell at a glance to what kind of crop each of these types is best adapted. We shall show further, that from this difference in texture, which is so very apparent to the eye, there is a marked difference in the relative rate with which water moves within the soil, and the ease with which the proper amount of water may be maintained and supplied to the crop.

As crops differ in the amount of water which they require, and in the amount of moisture in the soil in which they can best develop, this difference in the relation of these soil types to water probably accounts for the local distribution of plants.

In green-house culture the same kind of soil is used for all kinds of plants, but great judgment is required in watering the plants. Some plants require a very wet soil, others must be kept quite dry. The amount of water required will not be the same at different stages of development of the plant. During the earlier growing period the

soil is kept quite wet, but during the fruiting or flowering period the soil is kept much drier. Each class of plants requires in this way special treatment, and it is through this judicious control of the water supply in the soil and the temperature of the air, that the best development of each class of plants is attained.

Our soil types, therefore, in having different relations to the circulation of water, partake somewhat of these artificial conditions in green-house culture, and on each of them certain classes of plants will find conditions of moisture best suited to their growth and development.

Our soils have been formed from the disintegration, or decay, of rocks. The crystalline rocks, such as granite, gabbro and serpentine, from which the soils of Northern Central Maryland are derived, have been formed by the slow cooling of the earth's crust. They are made up of different minerals, the most common of which are quartz, feldspar and mica, cemented together usually with lime or silica. The kind of rock is determined by the kind and relative amount of each of these minerals of which it is made. When the rocks decay, the cementing material is dissolved and carried off, and many of the minerals themselves are changed. Now, the texture or the relative amount of sand and clay contained in the soil resulting from the disintegration of these rocks, will depend upon the kind of rock, that is, upon the minerals of which it was composed.

The material resulting from the disintegration of these rocks is slowly washed away and carried off by streams and rivers. As the current of water becomes slower near the sea, the sand is deposited along a rather narrow shore line, while the finer particles of clay are carried further and deposited over wider areas. The conditions where some parts of this material are being deposited may be favorable to the growth of coral and of various kinds of shell-fish, so that their remains accumulate in beds of great thickness, giving the material for the limestone of the present day. These sediments are thus assorted out by subsidence in water of different velocities, as though they had been sifted and the different grades of material spread out over wide areas.

The sediments, being slowly deposited in beds of great thickness, are converted into rocks through the agency of heat and great pressure to which they are subjected by the accumulation above, and so sandstones, limestones and shales have been formed; the sandstone,

where the coarser material has been deposited near the shore; the limestone, where the shells have accumulated; and the shale, where the fine mud has been spread out over a wider area of still water.

It is from the disintegration of these "sedimentary" rocks, as they are called, which have since been raised above the surface of the water, that the soils of Western Maryland have been formed. There are the limestone valleys, where shell-fish were once abundant, and where now is a strong clay soil, well adapted to grass and wheat; the sandstone ridges, some of which, resisting decay, form the mountain ranges, while others, made of finer grains of sand and less firmly cemented together, form some of the fertile hill and valley lands; the shales, in which the grains of mud were so extremely small that they adhere so closely to each other that they do not thoroughly disintegrate, and the soil is filled with fragments of the rock and supports but a scanty mountain pasture.

The soils of Southern Maryland and the Eastern Shore are of more recent origin. The sediments have not, as yet, been subjected to the great heat and pressure required in rock-making, and they are still in the first stages of formation.

Now, geology defines the limits and areas of these different formations and of these different rocks, and, as I have shown, that these rocks determine the texture of the soil, a thorough and detailed geological map of the State should answer for a soil map. Any one familiar with the texture of the soil, or kind of soil, formed by the disintegration of granite, gabbro, and the different kinds of limestones, sandstones and shales, should be able to tell by a glance at the map the position and area of each kind of soil. Each color on the map would represent a soil formation of a certain texture, in which the conditions of moisture, under our prevailing climatic conditions, would be best adapted to a certain crop.

Such a geological or soil map would be of the greatest aid to any one interested in the agricultural lands of the State. It seems to me that such a map of the soil formations in this State would be of great benefit to agriculture in the hands of farmers and of those interested in immigration and in the material advancement of the agricultural interests of the State. Not only so, but I think the interest of this work demands the most thorough and detailed geological survey so that each of these soil formations may be carefully located and outlined. The wheat, tobacco, truck and barren lands of Southern

Maryland are each confined to certain different geological formations for their best development, and a geological map of this portion of the State should show the area and distribution of the lands best adapted to these crops.

There is usually some marked and distinctive botanical character in the herbage of these different soil formations. We have pine barrens, white oak lands, black jack lands, chinquapin lands, grass lands, wheat lands and truck lands. These names convey a very good impression of the character and texture of the soil, and they should be more generally used. When a soil formation is spoken of as black jack land, the name conveys a distinct impression of the kind of soil, for a soil must have a certain characteristic texture to produce such a growth.

We have not been able to include this botanical work on the different soil formations of the State this year, but it will be made a subject of careful investigation. In the mean time and until a description better suited to the agricultural interests can be given, the geological names will have to be used to designate these different soil formations.

V. Soil Types.

The soils of the State appear, at first sight, to offer an endless field of research in the great variety often seen on a single farm and in the same field, but a more comprehensive view of the matter will show this to be due to local causes, which have mixed up and modified the original soil formation. These local modifications may be neglected for the present, until the general features of the representative soils of the region have been worked out.

The characteristic properties of great soil formations, or soil types, must first be determined, and then more detailed work may be done in the examination of soils of local interest. Why will not truck, tobacco, wheat and grass grow equally well on all soils? It is not so much a matter of plant food as of the texture of the soil. No addition of mere plant food in the form of fertilizers or manure will change at once a light sandy soil into a good wheat land. It takes no very great experience to tell at a glance the condition of a soil, and to what class of plants it is best adapted. It is from the *appearance* of the soil, that is, from the texture and structure, that this judgment is formed.

This is the key to soil investigations. It is not until this problem has been mastered and these very evident differences in soils have been explained, that the real and full value and application of the chemical determinations in plants and soils will be seen. As a rule, the chemical analysis of a soil will not enable a farmer to determine to what his land is best adapted; but, on the contrary, the farmer, from his experience and judgment, must inform the chemist on this point, and must tell him of the strength and condition of the land.

What are the characteristic properties of a good wheat land, of the best tobacco soil, of the best grass land, of the best land for market truck? What is it in the appearance of a soil which enables a farmer to place it in one or the other of these classes? The truck lands of Southern Maryland are "lighter" in texture than the best tobacco lands, and still "lighter" than the best wheat lands. The wheat lands of Southern Maryland are "lighter" than the grass and wheat lands of Northern and Western Maryland.

It is only after the characteristic properties of a number of soils of well marked agricultural value have been carefully determined that we may hope, by examination and comparison, to suggest methods for the improvement of other soils of local interest. We must have, first of all, a basis of comparison in well known and representative soils.

We have made several extended trips into Southern and Western Maryland, collecting a large number of samples of soils and sub-soils of representative agricultural value and importance. These samples have been arranged in groups, according to their agricultural value and their geological origin; and equal weights of the samples in each group have been mixed together, forming a composite sample representing the *type* of the soil formation. We have, in this way, classified the soils of all the principal agricultural regions of the State, and they are represented by comparatively very few type samples, as shown in the following table:

The formations are not given in the order of their geological origin but according to their agricultural importance and distribution.

TABLE 3:—SOIL TYPES IN MARYLAND.

SAMPLE.	SOILS ADAPTED TO,	LOCALITIES.	GEOLOGICAL FORMATION.
276.	Pine barrens.	* (2)	Lafayette.
283-4.	Market truck.	(6-8)	Eocene.
285-6.	Tobacco.	(9-9)	Neocene.
279-80.	Wheat.	(7-14)	Neocene.
277-8.	Wheat soil of river terraces.	(5-5)	Columbian terrace.
.....	Barren clay hills.	.....	Potomac.
.....	Grass and wheat.	.....	Trenton chazy limestone.
287-8.	Grass and wheat.	(2-4)	Helderberg limestone.
238.	Grass and wheat.	(1)	Catskill.
281-2.	Grass and wheat.	(4-5)	Triassic red sandstone.
290.	Mountain pasture.	(3)	Oriskany.
289.	Poor mountain pasture.	(6)	Chemung, Hamilton, Niagara, Clinton.

The Lafayette, Eocene, Neocene and Columbian terrace formations occur in Southern Maryland; the Potomac formation is a narrow belt extending across the State on the line of the B. and O. and the B. and P. railroads; the Trenton chazy limestone forms the Frederick and Hagerstown Valleys; the Triassic red sandstone covers a considerable area to the north and south of the Frederick Valley; the Helderberg limestone, Catskill, Oriskany, Chemung, Hamilton, Niagara and Clinton formations form the valleys, hills and mountains of Western Maryland.

In the Piedmont Plateau of Northern Central Maryland, there are grass and wheat soils from gneiss, granite, gabbro and limestone; wheat and tobacco soils from mica schist; corn lands from sandstone; and barren hills from serpentine.

There has been no opportunity this year to collect samples of soils from the Eastern Shore.

There are two or three mountain formations which occur in such small areas that their soils have not been considered here. The coal formation is so uneven, with its succession of sandstones, limestones

and shales, which have not been separated on the geological map, that, although it is of importance from covering a large area, it has not, as yet, been considered.

The coarse sands of the quarternary formation, covering the extreme lower part of the State, have not been sampled.

In the table, where a double number is given, the first number refers to the sample of soil, and the second number to the subsoil. Where a single number is given for a type, there is no perceptible difference between the soil and subsoil in the localities visited.

The figures in brackets under * give the number of localities from which samples were taken to make up the samples of type soils and subsoils.

The grass and wheat soils of the different types in the Piedmont Plateau and Western Maryland differ in texture and in relative fertility, and should be distinguished by different botanical characters, but for the present the geological names will be used to designate them.

The truck, limestone and Catskill lands are important soils, which should have more localities represented in the type samples.

To establish a type, samples should be taken from as many localities as possible; from ten localities at least, even in as small a State as Maryland. The type sample is, therefore, a sort of composite sample made by mixing equal weights of samples from a number of localities in each formation.

A description of the samples themselves will be given later. They were taken with a spade, or auger, the *soil* being taken down to the change of color, and the *subsoil* below this to a depth depending upon the nature and depth of the material, usually 12 to 18 inches.

The soil of the pine barrens is a coarse yellow sand, very loose and incoherent when worked, but packed exceedingly hard and tight in the subsoil. The lands are very infertile. These soils should be more carefully examined, and more samples of them should be taken for our type sample, as they cover such an extensive area in Southern Maryland with pine barrens, which will some day, when agricultural lands rise in value, have to be taken up and improved.

Most of the truck supplied to the Baltimore and the larger Northern markets, from this State, is produced on a rather narrow belt bordering the Bay and rivers from Baltimore south to West River. This area is largely in the eocene formation, although far down on

the river necks the lands are coarser and belong to a more recent formation.

The truck lands proper are a fine textured, grey or reddish grey, sand. They are naturally fertile, but require care to keep up their fertility. The texture of the soil admits of vast quantities of manure and organic refuse being used for forcing the vegetables, without fear of clogging the soil. The texture of these lands adapt them well to the requirements of market gardening.

The soils are derived from the weathered green sands, similar in composition to the green sand marls of New Jersey, so that in chemical composition they should be rich in potash and phosphoric acid.

The soils are too light in texture for wheat, although, in the high state of cultivation to which they are brought for market truck, good crops of wheat may be produced, but at such a cost, and under such artificial conditions, that the soil cannot, in any sense, be called a wheat soil.

Samples have been taken from too few localities in the truck area to make the type samples of soil and subsoil (Nos. 283-4) perfectly satisfactory. They are probably heavier than the best type of truck land. The collection of these samples has been rather incidental to other work, as most of our attention has been given this year to the tobacco and wheat soils of Southern Maryland. The great truck area between Baltimore and Annapolis is not represented in these samples.

The best tobacco and wheat lands in Southern Maryland, apart from the river terraces, seem to be confined to the diatomaceous earth horizon of the neocene formation, or of a later formation made over out of this same material. The formation extends obliquely across the peninsula, in rather a broad belt from South River and Herring Bay to Pope's Creek on the Potomac River.

The subsoil of the wheat land is a strong clay-loam of a very marked and characteristic texture and yellow color. It is usually not more than 4 to 6 feet deep, resting directly on the white diatomaceous earth, and appears to be formed from this by weathering, as there is no distinct line of separation. The samples of both wheat and tobacco subsoils still contain many diatoms. The weathering of this diatomaceous earth probably takes place quite rapidly on exposure, and some interesting changes occur, including a local accumulation

of clay in the yellow subsoil, which should be further studied. We have the material for this work, but it has not been worked out yet.

Wheat and tobacco are commonly grown on the same land in alternate years or in longer rotation, but the strongest and best wheat land is too heavy for tobacco. It gives a large yield but makes a coarse, thick tobacco leaf which is sappy and cures green and does not take on color. The best class of tobacco lands, where the finest grade of tobacco is produced, is of lighter texture and too light for the best wheat production. The best tobacco soils around Upper Marlboro appear to be at a lower elevation than the strongest wheat lands, and are rather heavier in texture than the better grade of tobacco lands in the Nottingham, Aquasco and Chaneyville regions. These latter are more loamy, although they are still over very pure deposits of diatomaceous earth.

At a road cut near Upper Marlboro there is an exposure of diatomaceous earth, probably 30 or 50 feet deep. The upper part of this exposure is very pure white earth, very light and porous. A strong wheat subsoil rests directly on this. The lower part of the exposure is decidedly more sandy in texture, and more like the typical tobacco land. The lighter texture of the tobacco soils may be due to local modifications of original wheat lands, or they may themselves turn into good wheat soils by further weathering, or these tobacco lands may belong to a different horizon of the diatomaceous earth formation. The last seems very probable, but it may be due to different causes in different localities.

Lime is the great fertilizer for all classes of soils in this region. On the lighter soils lime must be used only with organic matter, or it will "burn out the land." Lime every five years, and clover, will keep up their wheat lands. But this rule is being neglected. Lime is applied more rarely and the lands are becoming clover-sick. The wheat and tobacco lands are deteriorating. This cannot be due solely to a loss of plant food from the soil, for there is undoubtedly a change of texture of the soil, very apparent to the eye, which must change the relation of the soil to the circulation of water and to crop production. What these changes are which take place in the soil, must be fully investigated and must be well understood before the most intelligent methods can be proposed for the recovery and improvement of the lands.

The fertile terraces bordering the rivers of Southern Maryland are very level and very uniform in appearance. They extend about half

a mile inland from the rivers. The soil is a fine grained loam and the subsoil a yellow clay loam. It would be classed as a good strong wheat soil, very easily worked and naturally very fertile and capable of the highest state of cultivation. They are similar in appearance to the "ridge lands" of the south. Recently the fertile valley lands along the B. & O. R. R., between Baltimore and Washington, (heretofore considered part of the Potomac formation,) as well as other lands in the vicinity of Baltimore, have been classed with the Columbian terrace formation, but these localities are not represented in our type samples.

The barren clay hills crossing the State in a broad belt from Washington, along the two railroads, to the Delaware line, belonging to the Potomac formation, have not been sampled.

The fertile soils of the Frederick and Hagerstown Valleys, formed by the disintegration of the Trenton limestone, are very heavy, red clay, well suited to grass and wheat, They are much stronger than the wheat lands of Southern Maryland. It takes a strong, heavy soil for grass and these are naturally good grass lands. We have a number of samples from different localities but not enough to make a satisfactory type sample.

The Triassic red sandstone covers a considerable area to the north and south of the limestone formation in the Frederick valley, with a dark, indian red, heavy clay soil. It is very productive but is not so safe or certain as the limestone soil. Like the limestone soil, it is greatly benefited by an application of lime.

The Helderberg limestone (cement rock) forms a small area of fertile hill and valley lands west of Hagerstown. The subsoil is a strong yellow clay, naturally well drained, and capable of a high state of cultivation. The land is well adapted to grass and wheat.

The soil appears very uniform in texture and the type sample is considered fairly satisfactory.

The Catskill formation gives a very strong soil, well suited to both grass and wheat. It has a very characteristic dark red color.

The other formations are found in narrow belts forming the hills and mountain ranges, and, so far as I have seen, they are generally very poor and stony. There is often no perceptible difference between the soil and subsoil of these mountain formations, and where they cannot be distinguished, a sample is taken down to 12–18 inches and classed with the subsoils.

A description of the soils and subsoils which have been used to make up the type samples.

Pine Barrens.

276. Type sample from the following localities:

209. Coarse yellow sand and gravel overlying neocene at Cove Point, three miles north of Drum Point.
210. Coarse yellow sand from bluff at Jones' wharf, Patuxent River.

Truck Land.

283. Type sample of SOIL *from the following localities:*

144. Sandy soil from Patuxent, near Governor's Bridge. Naturally rather poor and unproductive but would make good truck and is typical watermelon land.
167. Sandy soil from a peach orchard at Mitchellville.
170. Soil of light lands west of Hall's Station. From the farm of J. Berry. Very characteristic truck land and of considerable area here.
267. Soil of truck land from farm of J. Birch, South River Neck.
269. Sandy soil of truck land, South River Neck.
271. Soil of truck land east of Hill's Bridge.

284. Type sample of SUBSOIL *from the following localities:*

145. Sandy subsoil from near Governor's Bridge. Under 144.
158. Subsoil of pine land on the "Ridge road" near Cheltenham. A compact red sand which should make good truck land. There is a large area of this land here, probably of Lafayette or possibly of neocene origin.
166. Subsoil from B. D. Mullikin's farm, between Hall's Station and Mitchellville. Characteristic truck land of that region, showing green grains of glauconite and of undoubted eocene origin.
169. Subsoil from peach orchard at Mitchellville, from under 167.
171. Subsoil of light lands west of Hall's Station, under 170.
268. Subsoil truck land, from under 267, from the farm of J. Birch South River Neck.
270. Subsoil of truck land, from under 269, South River Neck.
272. Subsoil truck land, from under 271, east of Hill's Bridge.

These soils and subsoils are undoubtedly of eocene origin except 158, and possibly 269 and 270, which were far down on the Neck and may be of more recent origin.

Tobacco Land.

285. Type sample of SOIL *from the following localities:*

145. Soil from Chas. W. Sellman's farm near Davidsonville. Rather light for wheat but makes good tobacco and corn.

161. Loam soil from J. H. Sasscer's farm near Upper Marlboro. A deep loam, lying rather low and much lighter than the best wheat lands. It is a fair type of the tobacco lands of Marlboro district, but is rather heavy for tobacco, making rather a heavy, coarse leaf. It is heavier than the Nottingham or Chaneyville tobacco lands Wheat, on this land, is inclined to go to straw and not produce much grain.

163. Soil of H. H. Sasscer's tobacco land, North Keys. Considered rather heavier than the best type of Nottingham tobacco land. It makes a very fine grade of tobacco.

255. Loam soil from W. H. Hopkins, Bristol. Light in texture and a very fine quality of tobacco land. Considered very fertile but rather light for wheat.

257. Soil of tobacco land from Fred. Sasscer's farm, Upper Marlboro.

259. Soil of tobacco land from the river terrace at Nottingham. The soil is coarser than most of the river terraces examined. This grade of soil appears to be of rather small area. The terraces extend about half a mile inland from the river and produce a fine quality of tobacco.

261. Soil from a farm near Chaneyville. It is considered the very finest grade of tobacco land.

263. Soil of a fine grade of tobacco land near Nottingham.

265. Soil of a very fine type of tobacco land from the farm of J. F. Talbott, Chaneyville.

286. Type sample of SUBSOIL *from the following localities:*

Samples 148, 162, 164, 256, 258, 260, 262, 264, 266, from under the soils just given, and in the corresponding order.

These soils and subsoils are of neocene origin or formed of neocene material, except 259, 260, 263, 264. Diatoms were found in most of the subsoils. The finest tobacco lands are lighter in texture than the best wheat lands.

Wheat Land.

279. Type sample of SOIL *from the following localities:*

140. Loam soil from near Davidsonville, fairly representing the wheat lands of this locality. It appears somewhat light for wheat, and is not considered as productive as it was years ago. It does not produce the clover crops it once did, which were such an excellent preparation for wheat. The lands have deteriorated. The finest wheat lands now are the hill lands where this loam has not accumulated, or has been removed by subsequent washing, leaving exposed a yellow clay loam like 142.

154. Clay soil from J. H. Sasscer's farm near Upper Marlboro. Very fine wheat land, similar to the Davidsonville and West River lands. Too heavy for tobacco, the plant being sappy and curing green. These lands are of considerable area around Marlboro, extending up nearly to Mitchellville on the east of the railroad, and forming the bottom lands and hills, west of the Western Branch of the Patuxent, but becoming much lighter in texture south of Marlboro.

178. Clay soil at the base of the neocene, at Herring Bay. Good strong wheat land, very similar to the preceding localities.

183. Soil of wheat land from James Chapman, Pope's Creek. This land carries a good grass sod.

249. Soil of wheat land from J. F. Talbott, Chaneyville.

251. Soil of the fertile wheat lands of West River.

253. Loam soil from Mt. Zion. Very characteristic wheat land, similar to those of Davidsonville and West River.

280. Type sample of SUBSOIL *from the following localities:*

141. Loam subsoil from under 140, from near Davidsonville. It has good body but not the consistancy of the next sample. It fairly represents the lands around here where washing has not occurred. The loam is from two to four feet deep.

142. Yellow clay subsoil from under the above, taken in a road cut. This forms the very best wheat land when exposed. It has the very characteristic color and texture of the best wheat lands in Southern Maryland.

155. Clay subsoil of wheat land from under 154, from the farm of J. H. Sasscer, near Upper Marlboro.

156. Yellow clay subsoil under the "gravelly lands" of Rosaryville. This is undoubtedly neocene or neocene material. A fair quality of diatomaceous earth was found in a road cut near by, directly underlying this and gradually passing from the white earth into the yellow clay above. The country is covered generally with a thin layer of fine gravel, which is hardly noticed in cultivated fields and is often absent. The gravel extends down into the undisturbed clay and is probably part of the same formation, although there may be a light coating of Lafayette here, made out of the neocene material. The lands make a very fine quality of tobacco but are generally too light for wheat. When this clay is exposed without the gravel, however, it makes a very fine wheat land. On Mr. Holloway's place, between Rosaryville and Woodyard, and near where this sample was taken, they made a very fair quality of brick some years ago from the subsoil of the wheat field.

179. Clay subsoil of the wheat lands of Herring Bay, from under 178.

180. Yellow clay subsoil from over diatomaceous earth, from a bluff three miles north of Plum point.

184. Yellow clay subsoil of wheat land, from under 183, from the farm of James Chapman, Pope's Creek.

245. Subsoil f wheat land opposite the church at Davidsonville. It is in a fine state of cultivation.

246. Subsoil of wheat land about one half mile west of Davidsonville.

247. Subsoil of wheat land, now in grass, from the farm of James Iglehart, Davidsonville.

248. Subsoil of wheat land from the farm of P. H. Israel, Davidsonville.

250. Subsoil of wheat land from the farm of J. F. Talbott, Chaneyville. From under 249.

252. Subsoil of wheat land, from under 251, South River.

254. Subsoil of wheat land, from under 253, Mt. Zion.

River Terrace.

277. Type sample of SOIL *from the following localities:*

198. Loam soil from a wheat field opposite Benedict.

200. Loam soil from a corn field below St. Mary's. This soil is naturally fertile and is capable of great improvement. An excellent wheat soil.
202. Loam soil from Mr. Broome's wheat land, St. Mary's.
204. Loam soil from a wheat field opposite St. Mary's.
206. Loam soil from Clifton Beach. Good wheat land.

278. Type sample of SUBSOIL *from the following localities:* Samples 199, 201, 203, 205, 207, are subsoils from under the above soils, given in the same order.

HELDERBERG LIMESTONE.

287. Type sample of SOIL *from the following localities:*
221. Soil from near Hancock. Very fertile grass and wheat land.
222. Soil from near Hancock.

288. Type sample of SUBSOIL *from the following localities:*
220. Very fertile grass and wheat land two miles west of Hancock. No change in 18 inches.
223. Subsoil near Hancock.
224. Characteristic yellow subsoil of the Helderberg limestone, from a wheat field two miles west of Hancock. Contains many small fragments of undecomposed rock.
225. Subsoil from near Cumberland. Naturally rather poor but has good body and is very fertile where improved.

CATSKILL.

238. Type sample of the Catskill formation, from near Mt. Savage. Good strong land for grass and wheat. Has a characteristic, dark red color.

ORISKANY.

290. Type sample of Oriskany from the following localities:

226 and 227, from near Cumberland, and 228, from Hancock. The formation is not very uniform in texture. The localities visited have rather a fine textured soil, naturally poor but capable of some improvement. The formation occurs only in narrow belts capping hills and mountains, and is not of much extent in the State.

Chemung, Hamilton, Niagara and Clinton.

289. *Type sample from the following localities:*
234. Subsoil of the Hamilton shale, from near Mt. Savage. Naturally very poor but capable of some improvement as it has good body.
235. Hamilton shale, from Cumberland. Poor lands—mostly thin mountain pastures.
236 and 237, Chemung from two localities near Mt. Savage. Naturally rather poor land.
239. Niagara from near Cumberland. Poor but has good body and is capable of some improvement.
240. Clinton shale from near Cumberland. Lands naturally poor but have good body.

These formations appear so much alike in texture and agricultural features that they are all included in the one type. They are nearly all hill and mountain pastures, naturally poor and not capable of great improvement, except as garden spots and at great expense. The soil or rather subsoil, for there is little or no difference, is a very fine grained, powdery material, filled with small fragments of the original rock.

VI. Mechanical Analysis of the Type Soils.

The soils of these type formations differ so much in texture that the difference is quite apparent to the eye. Some are coarser than others, the grains are larger and there are fewer of them in a given weight of soil. The first thing done, in the examination of the soil, was to make a mechanical analysis by separating the grains into groups, according to size. The approximate number of grains in each group was then calculated and this shows how much the empty space in the soil has been divided up and, relatively, how fast water will move through the different soils.

For the greatest accuracy, the grains should be separated into a large number of groups, so that all the grains in each group shall be very nearly of the same size, but the analysis takes so long that we have used only eight groups. The separations were made substantially after Johnson and Osborn's "beaker method." We have taken .0001 mm. as the lowest limit of size of the grains of clay, based on many measurements we have made. The clay group has

relatively wide limits (.005–.0001 mm.) but we have not attempted a further separation than this. A millimeter (1 mm.) is equivalent to about 1-25th of an inch, so that the smallest grains of clay are about 1-25400 inch or .0000039 inch in diameter.

Table 4, gives the results of the mechanical analysis of the type samples of the subsoils of the five formations in Southern Maryland. The analyses and calculations based on the other type samples will not be completed in time for this report.* The subsoils have been taken up first, as the texture of the subsoil is more important in determining the nature of the land and its relation to the water supply of crops than that of the soil itself.

TABLE 4:—MECHANICAL ANALYSES OF TYPE SUBSOILS.

Diameter. *mm.*	Conventional names.	276. Pine barrens.	284. Truck.	286. Tobacco.	280. Wheat.	278. River terrace.
2–1	Gravel	†4.87	0.68	1.36	0.00	1.60
1–.5	Coarse sand	9.15	2.89	2.13	0.42	1.51
.5–.25	Medium sand	38.37	21.85	7.78	1.81	4.15
.25–.1	Fine sand	33.28	25.82	16.57	8.59	4.84
.1–.05	Very fine sand	3.52	18.38	19.83	32.06	8.54
.05–.01	Silt.	3.47	9.48	25.41	23.65	44.92
.01–.005	Fine silt	1.55	3.37	4.52	6.77	5.78
.005–.0001	Clay	3.75	15.30	17.95	22.55	25.85
		97.96	97.77	95.55	95.85	97.19
Organic matter, water, loss..		2.04	2.23	4.45	4.15	2.81

† This includes 1.81 per cent. larger than 2*mm.* in diameter.

NOTE.—Each of these type samples is made up of samples from a number of localities in each soil formation.

The results in this table are confusing from the mass of figures, and from the fact that each group has to be given a special value, depending upon the size of the soil grains which it contains; a per cent. of clay having far more value than an equal amount of gravel. From this table alone it would be difficult to judge of the texture of the soils.

VII. APPROXIMATE NUMBER OF GRAINS PER GRAM OF SOIL.

From the results in Table 4 we have calculated the approximate number of grains of sand and clay in one gram of the subsoils, as

*This matter has since been completed and will be given in an appendix.

given in Table 5. These figures are, of course, only approximate and the numbers are far beyond our comprehension. They may be used relatively, however, in comparing one soil with another.

TABLE 5:—APPROXIMATE NUMBER OF GRAINS PER GRAM OF SUBSOIL.*

Diameter. *mm.*	Conventional names.	276. Pine barrens.	284. Truck.	286. Tobacco.	280. Wheat.	278. River terrace.
2–1	Gravel	7	1	3	0	3
1–.5	Coarse sand	160	50	38	7	26
.5–.25	Medium sand	5 356	3 056	1 114	258	583
.25–.1	Fine sand	45 700	35 530	23 320	12 050	6 701
.1–.05	Very fine sand	61 380	321 200	354 500	571 200	150 200
.05–.01	Silt	945 900	2 589 000	7 101 000	6 588 000	12 340 000
.01–.005	Fine Silt	27 030 000	58 880 000	80 790 000	120 700 000	101 600 000
.005–.0001	Clay	1 664 000 000	6 806 000 000	8 170 000 000	10 230 000 000	11 570 000 000
		1 692 088 503	6 867 828 837	8 258 269 975	10 357 871 515	11 684 097 513

* There are about 453 grams in one pound.

It will be remembered that the texture of the soil is determined by the size and, therefore, by the number of grains per unit weight or volume of soil. In this table it will be seen that the number of grains in the fine "silt" and "clay" groups so far exceed the number in all the other groups combined, that they, and especially the clay, actually determine the extent of subdivision of the empty space in the soil. The other groups may be neglected, for practically, the effect of the gravel and sand, is only to diminish the amount of clay per unit weight or volume of soil. The amount of clay is, therefore, a very important factor in any soil as it practically determines the subdivision of the empty space and the texture of the land.

TABLE 6:—TOTAL NUMBER OF GRAINS IN ONE GRAM.

(*Summary of Results in Table* 5.)

276......	Pine barrens............	*(2)	1 692 000 000
284......	Truck..................	(8)	6 868 000 000
286......	Tobacco............ ..	(9)	8 258 000 000
280......	Wheat	(14)	10 358 000 000
278......	River terrace.....	(5)	11 684 000 000
....	Limestone (grass land)...	(1)	24 653 000 000

*Number of localities represented.

The summary of the results in Table 6 places the soils at once in their true agricultural relation. It suggests also a method for the classification of soils.

From the mechanical analysis of the samples which were used to make up these type samples, and perhaps of a large number of other soils of known agricultural value, it should be possible to determine the smallest and the largest number of grains per gram of soil where these different crops could be successfully grown. For example, no crop can be successfully grown, except under highly artificial conditions of manuring with organic matter, or by irrigation, on a soil having so few as *one thousand seven hundred million* grains per gram. Good market truck is grown on a soil having *six thousand eight hundred million* grains. Now what is the limit between these two figures where the soil becomes too light for market truck? Good wheat is grown on a soil having *ten thousand million* grains per gram, and this must be near the limit of profitable wheat

production, for *eight thousand million* grains per gram gives a soil rather too light for wheat, but well suited to tobacco. A soil having *ten thousand million* grains per gram is too light for grass, which thrives on a limestone soil having *twenty-four thousand million.* Our type soils should, therefore, show the range for the profitable production of a given crop. We should be able also from the mechanical analysis of an unknown soil to give it its true agricultural place by reference to these established soil types.

It is not to be inferred from these statements that wheat cannot be grown on a soil having so few as *one thousand million* grains per gram. This number represents merely the skeleton, or framework, of the soil. As we shall see later, this may be so filled in and modified by organic matter as to enable it to support a good wheat crop, but at such an expense as to put it far outside the limit of profitable culture. This is a matter of judgment and experience. The soil types give only the skeleton structure of the soil.

Nor is it to be inferred that wheat may be grown on all soils having *ten thousand million* grains or more per gram with equal success, for the relation of these soils to water, upon which the cropping depends, is a matter not only of how much the space within the soil is subdivided, that is, how many grains there are, but depends also upon the way these grains are arranged. We will develop this idea further, when we come to speak of the cause of the deterioration of lands and of their improvement.

VII. Approximate Extent of Surface Area per Cubic Foot of Soil.

We are able, from the foregoing results, based on the mechanical anlysis of the soils, to calculate the approximate extent of surface area of the grains of clay and sand in a given weight or volume of soil.

A solid block of granite, one foot square and one foot high, would have six square feet of surface area, but when this cube of solid rock disintegrates, forming or leaving a cubic foot of soil, half of the rock is dissolved and carried off and what remains is split up into a vast number of separate grains of sand and clay. If a soil were made up of fragments as large as this cubic foot of rock, then, even if the proper water supply could be maintained in the soil, it would be impossible for our staple crops to get their needed food supply. The soil moisture and the roots themselves can only dissolve food

material from the surface of the rock. The rock is exceedingly insoluble and the amount of plant food which could be dissolved and extracted from six square feet of surface by water or roots, would be exceedingly small and entirely insufficient for the needs of any of our staple crops.

The soil, however, resulting from the disintegration of such a rock has an enormous extent of surface area if all the surface on the separate grains of sand and clay be considered. Table 7 gives the approximate extent, in square centimeters, of the surface area in one gram of our type subsoils and of a limestone subsoil from Frederick Valley. Table 8 shows the approximate number of *square feet* of surface area in *one cubic foot* of soil.

TABLE 7:—SURFACE AREA (*sq. cm.*) PER GRAM OF SUBSOIL.

Diameter. *mm.*	Conventional names.	276. Pine barrens.	284. Truck.	286. Tobacco.	280. Wheat.	279. River terrace.	...... Limestone.
2–1	Gravel	0.5	0.1	0.2	0.0	0.2	0.0
1–.5.	Coarse sand	2.8	1.0	0.7	0.1	0.5	0.0
.5–.25	Medium sand	23.6	13.5	4.9	1.1	2.6	0.1
.25–.1	Fine sand	43.9	34.1	22.4	11.6	6.4	0.4
.1–.05	Very fine sand	10.8	56.7	62.5	100.9	26.5	7.6
.05–.01	Silt	26.7	73.1	200.7	186.2	348.7	221.3
.01–.005	Fine silt	47.7	104.1	142.8	213.2	179.5	344.3
.005–.0001	Clay	339.8	1387.0	1668.0	2089 0	2360.0	5000.0
		495.8	1669.6	2102.2	2602.1	2924.4	5573.7

TABLE 8:—SQUARE FEET OF SURFACE PER CUBIC FOOT OF SUBSOIL.

276	Pine barrens....	23 940 square feet.
284......	Truck..........	74 130 " "
286......	Tobacco.........	84 850 " "
280	Wheat..........	94 540 " "
278......	River terrace....	106 200 " "
		(2.3 acres.)
....	Limestone.......	202 600 square feet.
		(158 000 acres.)

It will be seen that there are upwards of 24,000 square feet of surface area in a cubic foot of the subsoil of the pine barrens, no less than 100,000 square feet, or 2.3 acres, of surface area in a cubic foot of the subsoil of the river terrace, and 158,000 square feet of surface area in a cubic foot of the limestone subsoil.

These figures seem vast, but they are probably below, rather than above, the true values on account of the wide range of the diameters of the clay group, as given in the table. This gives an enormous area for the roots and soil moisture to act on for the extraction of plant food from the mineral elements of the soil. Instead of the few square feet offered by the cube of granite, there are now several acres of surface area, for the roots to range over, in search of food and for the water to act on, in a single cubic foot of soil. This great extent of surface and of surface attraction, which has been described as potential in Section II., gives the soil great power to absorb moisture from the air, and to absorb and hold back mineral matters from solution. A smooth surface of glass will attract and hold, by this surface attraction, an appreciable amount of moisture from the surrounding air. A cubic foot of soil, having 100,000 square feet of surface, should be able to attract and hold a considerable amount of moisture from the air.

When a soil is only slightly moistened with water there will be nearly as much exposed water-surface as the surface of the soil grains themselves. The amount of energy or tension on such an extent of water-surface will be very great and it is this which enables a soil to draw up the large amount of water needed by the crop.

In all of these relations, the extent of surface gives the soil a certain strength and value which must have an important bearing on crop production and distribution.

IX. The Circulation of Water in these Type Soils.

We have shown that the number of grains per gram, places these type soils in their true agricultural relation. We have now to show the reason for this in the difference in their relation to the circulation of water, and the ease with which a definite quantity of water can be supplied to a given crop.

We will assume that the grains in all the soils have the same mean arrangement, then the relative rate of circulation, other things being equal, will depend upon how much space there is in the soil and upon how much this space is subdivided.

For the reasons which have already been given, we have not been able to determine the amount of space in the soils which were used to make up the type samples. The determinations require much time and great care to remove a definite volume of soil from the field, and this must be made the subject of some future investigation. From our work in South Carolina on similar soils, which has been referred to, we have assumed the per cent. of empty space in each of the soil types, given in the following tables. These values, therefore, are not exact determinations, but are thought to be approximately correct. It is important to observe that the coarser soils have less space and, consequently, when this space is completely filled with water, the sandy soils will contain less water than the clay soils. In a cubic foot of the sandy soils there is considerably less than half a cubic foot of empty space; in the same volume of the clay soils there is *over* half a cubic foot of space for water to move in. This difference in the amount of space in the different soils, gives rise to an important modification of the relative rate of circulation, when the soils are saturated, and when they are short of saturation.

The empty space in agricultural soils is hardly ever completely filled with water. The most favorable amount of water in the soil, for growing plants, as Hellriegel and others have shown, is from 30 to 50 per cent. of the water-holding capacity of the soil. As a light sandy land has less space and will hold less water than a clay soil, the most favorable amount of water for vegetation will be less than in a clay soil. We have repeatedly found in actual determinations, less water in light lands than in heavy clay soils, and it is a matter of observation and experience that light lands are drier than heavy clay soils.

The reason for this follows from the fact that water circulates more freely in these light soils, by reason of the fewer grains and the less amount of subdivision of the empty space, and after a moderate rain the water passes down more readily into the lower depths of the subsoil.

After the excess of rainfall has passed down through the soils and, equilibruim is established, there will be less water in the light lands than in the clay soils. If, then, a definite quantity of water is required, by the crop in a given time, it can move up to the plant through the sandy soil more readily, but there is less *water-surface* in the light land to contract, that is, there is less force to pull the

water up. These points are well brought out in the following calculations of the relative rate of circulation of water in these type subsoils.

If we assume in the first place, that all the soils contain the same amount of water, namely 12 per cent. (the most favorable amount in the wheat land,) the relative rate of circulation will be as follows:

No.	Soil.	Space.	Water-content.	Relative time.
276....	Pine barrens....	40 per cent.	12 per cent.	17
284....	Truck	45 " "	12 " "	43
286....	Tobacco	50 " "	12 " "	68
280 ...	Wheat..........	55 " "	12 " "	92
278....	River terrace....	55 " "	12 " "	100

If it takes 100 minutes for a quantity of water to pass down through a certain depth of the subsoil of the river terrace, the same weight of water could pass down through the subsoil of the truck land in 43 minutes, and through the subsoil of the pine barrens in 17 minutes. It could not move up so readily for there is less *water surface*, as we have shown, to contract and pull it up from below.

When equilibrium is established and the water is moving down with about the *same rate* in each of the subsoils, there will be about 6.5 per cent. in the subsoil of the pine barrens, 9 per cent. in the truck land and 12 per cent. in the subsoil of the river terrace, as follows:

No.	Soil.	Space.	Water-content.	Relative time.
276....	Pine barrens....	40 per cent.	6.6 per cent.	102
284....	Truck	45 " "	9.0 " "	102
286....	Tobacco........	50 " "	10.5 " "	102
280....	Wheat.	55 " "	11.7 " "	101
278....	River terrace...	55 " "	12.0 " "	100

This would be about the relative amount of water found in these subsoils some time after rain. When the subsoil of the river terrace contains 12 per cent. of water, that of the pine barren would contain about 6.5 per cent., that of the truck land, 9 per cent.

The interesting question suggested above, comes up here again. If the rate of circulation of water through the light truck land with 9 per cent. of water present in the subsoil, is the same as in the wheat

soil of the river terrace with 12 per cent. of water, (the most favorable amount for wheat), then why are not the light truck lands as good for wheat as the other? And the explanation given above is only made clearer through these tables, that while gravity acts with a constant force, *with* surface tension, to pull the water down, surface tension alone has to pull the water up to the crop *against gravity;* and there is less surface tension, less contracting power, less force, to pull up a given weight of water in a given time in the light land than in the other. The wheat crop would suffer on such a soil in a warm, dry spell, when it had to depend on water being supplied it from below.

We have shown that there is less space in the light truck land than in the wheat soils, but the soil grains being larger, there are fewer of them, and the space is not divided up so much. Each separate space is larger and, when the soil is short of saturation, the water moves faster.

If however the soils are fully saturated, the volume of empty space has an important value in retarding the rate of movement. There is less volume of space in the light lands, less water can be crowded into it than in the wheat soils, and so, when the spaces in the soils are fully saturated, the rate of movement will be relatively slower than in the wheat soils.

The relative rate of movement of water through these different subsoils when all the space is filled with water, will be as follows:

No.	Soil.	Space.	Water-content.	Relative time.
276..	Pine barrens..	40 per cent.	20.10 per cent. (Sat.)	63
284..	Truck........	45 " "	22.41 " " "	120
286..	Tobacco	50 " "	27.42 " " "	103
280..	Wheat	55 " "	31.55 " " "	92
278..	River terrace.	55 " "	31.55 " " "	100

If all the space is filled with water, as assumed in Table 9, the subsoils will contain, respectively, 25, 28, 31, 33, and 33 pounds of water per cubic foot. If a given quantity of water passes down through a depth of saturated subsoil of the river terrace in 100 minutes, it would take about 120 minutes for the same quantity of water to go down through the same depth of the saturated subsoil of the light truck land. This probably explains a matter of common observation and experience, that crops on light sandy lands are more

injured in excessive wet seasons than crops on heavier soils. The excess of water cannot be removed so fast by the light lands, when saturated, as in the heavier soils.

There are other interesting lines of thought, and explanations of other matters of common observation and experience, suggested by this line of reasoning, which may be followed out at another time as the limits of this report allow of only a concise narrative account of the work and a very general statement of the application of the results.

X. The Improvement of Soils.

When we consider that desserts are barren only from the lack of water and that where water is supplied they become fertile and productive as other lands; and when we consider the immense crops raised in dry and arid countries by irrigation as well as the difference in the yield of crops in our own state, in wet and in dry seasons, and other evidences which will be published at another time, we are forced to the conclusion that vegetation is very largely dependent for its developement and growth upon a proper water supply, and that the whole art of cultivation and manuring is based upon the possible control of the water supply within the soil.

We have shown the principles upon which this control is based; we come now to an application of these principles to the improvement of soils.

The agricultural lands of this state have generally good surface drainage. They have a small quantity of organic matter which is fairly uniform in amount in the soils of the different soil formations. If such a soil is shown by a mechanical analysis to have not less than *ten thousand million* grains per gram, it has the structure, or frame work, for a good wheat soil and should be classed as such. If it does not produce good wheat crops, or if it has deteriorated from a more fertile condition, there may be some change in the structure of the soil through a change in the arrangement of the soil grains.

The case must be studied as a physician considers the condition of a sick person; a diagnosis must be made to determine the cause of the trouble. The symptoms both of the soil and of the crops must be carefully studied. If the soil is rather close and too retentive of moisture, the plants are large and sappy and give a small yield of fruit or seed in proportion to the size of the plant and the amount of

food material gathered by the plant from the atmosphere and soil. The crop is also inclined to be late it maturing.

If the soil is dry and leachy, the plants are small and give a small yield, but the yield is relatively larger in proportion to the food material that has been stored up.

Other symptoms, besides this relation of the yield of grain and fruit to the size of the plant, that is, to the amount of food material stored up by the plant, offer evidence as to the condition of the soil and the changes needed for its improvement, such as the vigor of the plant, the way it develops and grows, the diseases and insect ravages to which it is subject, and the influence of wet and dry seasons on the crop production.

The cotton crop at the South is very sensitive to these conditions of environments. The wheat crop more readily adapts itself to the conditions under which it is grown, and is, therefore, not so sensitive or reliable for showing up these soil conditions.

There is need of an instrument, or a method, to show the actual rate with which water moves both up and down within the soil in its natural position in the field, and such a method must be devised, for the information is of great importance.

It has been shown how the relative rate of circulation of water may be calculated from the mechanical analysis of the soil. If this calculated rate could be compared with the actual rate of circulation in the soil in the field, it would indicate the relative arrangement of the soil grains, so that if we had such a method there would be no such necessity for studying the symptoms of the plant to tell in what direction, and how far, the conditions in a soil have departed from the typical conditions required by a given crop, or natural to the soil formation.

If the rate of circulation of water within the soil is shown, by actual observation or by its effect upon plants, to be slower than the rate calculated from the mechanical analysis, and slower than the rate of circulation in the typical soil for that crop, the texture of the soil may be changed by changing the arrangement of the soil grains. The smallest grains may be drawn closer to the larger ones, making some of the spaces larger and others exceedingly small. Lime, kainite and phosphoric acid seem to have this effect, as their continued use makes the soil more loamy, looser in texture, and less retentive of moisture.

Many of our agricultural lands need improvement in the other direction, they need to be made closer in texture and more retentive of moisture. We have found that ammonia, the caustic alkalies, carbonate of soda, and probably many other substances, possibly organic substances in general, tend to prevent this flocculation and to push the smaller grains further apart, making the spaces within the soil of a more uniform size and thus retarding the rate of circulation of the soil moisture. We cannot say what practical value this will have in its application to agriculture until more work has been done.

When a solution of organic matter comes in contract with lime, kainite, acid phosphate, and with certain soils, the organic matter is precipitated from solution in light, bulky masses, and these masses may fill up the spaces within the soil with solid matter which not only retards the rate of circulation of water downward by gravity, but, by increasing the extent of water-surface within the soil, it also assists in pulling water up from below.

If so much organic matter is added to the soil that it cannot be curdled or precipitated from solution, it may be injurious in the soil by reducing the surface tension of the soil moisture, the force which draws the water to the plant as needed. The judicious use of lime, kainite or acid phosphate, along with the organic matter, will insure the precipitation of the organic matter from solution and thus give a value to the application which it would not otherwise have had.

This gives a value to stable manure, out of all proportion to the amount of plant food which it contains. Lime, also, either alone or when acting with organic matter, has a distinct value for all classes of land. The nitrogenous matters in the stable manure, and in other organic matters, would determine the value as a fertilizer, for it is only the nitrogenous compounds which are so easily precipitated from solution by the mineral matters of the soil and of fertilizers. If the carbohydrates, such as starch, sugar and woody fibre, could be as readily precipitated from solution in light, bulky masses, by lime and the mineral matters of the soil, then sawdust or other organic refuse containing little nitrogen, would have nearly the same fertilizing value as the more expensive nitrogenous materials.

The whole history of plat experiments shows that it is not the plant which is to be manured for, but the soil conditions must be changed to produce the plant.

The corn plant on one soil requires potash, on another soil, phosphoric acid, on another soil, nitrogen, and again on another soil a combination of two or more of these fertilizers. On the whole, there is no such fertilizer in our State for wheat as lime, used alone or acting with organic matter.

Plat experiments frequently give a larger yield when lime, salt or plaster is used, and even when nothing at all has been added to the soil, than when the more expensive plant foods have been used. Especially when acid phosphate or potash has been used alone, the yield is often smaller than where nothing has been added to the soil.

Under ordinary conditions, our crops do not require special plant foods, but they all have somewhat different habits of growth and development and can best gather food under somewhat different physical conditions. We have seen how these different fertilizing materials change the physical conditions in the soil.

This opens up a new and wide field for investigation in the study of the physical conditions of the soil in their relation to plant growth and developement, and the effect thereon of the different fertilizers and manures. It will be through this study that the true theory of fertilization will be seen, and an interpretation and added value be given to the immense amount of chemical data, which has accumulated, relating to the soil.

Correction:—Through an oversight, part of the explanation of the phenomenon of flocculation on page 258 was transposed. It should read as follows: If the potential of the surface particle of water is less than of a particle in the interior of the mass of liquid, there will be surface tension, and the two grains will come together and be held with some force, as their close contact will diminish the number of surface particles in the liquid. If, on the other hand, the potential of the particle on the surface of the liquid is greater than the potential of a particle in the interior of the liquid mass, the surface will tend to enlarge, and the grains of clay will not come close together, as their close contact will diminish the number of surface particles in the liquid around them.

M. W.

APPENDIX.

Since the main part of my report was written, I have been able to secure the services of Mr. F. P. Veitch and Mr. J. B. Latimer, graduates of the class of 1891 of the Agricultural College. Mr. Veitch has completed the mechanical analysis of our type subsoils, which enables me to present the results here, with a short discussion.

The mechanical analysis of these type subsoils, given in Table 13, is based upon the "fine earth," or material smaller than 2 *mm.* in

TABLE 10:—MECHANICAL ANALYSIS OF TYPE SUBSOILS.

Diameter. *mm.*	Conventional names.	276. Pine barrens.	284. Truck.	286. Tobacco.	290 Oriskany.	280. Wheat.	278. River terrace.	282. Triassic.	238. Catskill.	289. Shales.	288. Helderberg limestone.
2–1	Gravel	*4.87	0.68	1.36	0.64	0.0	1.60	0.00	0.00	0.05	†1.34
1–.5	Coarse sand	9.15	2.89	2.13	0.81	0.42	1.51	0.23	0.11	0.16	0.33
.5–.25	Medium sand	38.37	21.85	7.78	3.50	1.81	4.15	1.29	0.42	0.80	1.08
.25–.1	Fine sand	33.28	25.82	16.57	23.97	8.59	4.84	4.03	2.63	2.01	1.02
.1–.05	Very fine sand	3.52	18.38	19.83	34.76	32.06	8.54	11.57	11.35	6.70	6.94
.05–.01	Silt	3.47	9.48	25.41	10.03	23.65	44.92	38.97	40.23	31.63	29.05
.01–.005	Fine Silt	1.55	3.37	4.52	3 03	6.77	5.78	8.84	10.90	14.24	11.03
.005–.0001	Clay	3.75	15.30	17.95	20.30	22.85	25.85	32.70	33.32	39.36	43.44
		97.96	97.77	95.55	97.04	95.85	97.19	97.63	98.96	94.91	94.23
Organic matter, water, loss:		2.04	2.23	4.45	2.96	4.15	2.81	2.37	1.04	5.09	5.77

*This includes 1.81 per cent. coarser than 2 *mm.*

†This includes 0.82 per cent. coarser than 2 *mm.*

diameter. Three of these subsoils were not thoroughly disintegrated, but contained small fragments of rock, which were separated out and weighed, the remaining fine earth being used for the mechanical analysis. The samples contained the following per cent. of coarse and of fine material.

	290	238	289
	Oriskany.	Catskill.	Shales.
Coarser than 2 *mm.*	5.80	21.28	17.23
"Fine earth".....	94.20	78.72	82.77

We have not, as yet, attempted to study the effect of these fragments of rock upon the relation of the soils to the movement of water, but have confined ourselves to the simpler study of soils having no coarse fragments, and we will, therefore, disregard this coarse material for the present, and treat the soils as though composed only of the fine earth. It may well be, that in some localities disintegration has gone further than where these samples were taken, and that these same soil formations there contain no coarse fragments of the undecomposed rock. Our results should apply directly to such a soil.

Table 11:—Approximate Number of Grains in One Gram of Subsoil.

276.	Pine barrens.	1 692 000 000
284.	Truck.	6 868 000 000
286.	Tobacco.	8 258 000 000
290.	Oriskany.	9 154 000 000
280.	Wheat.	10 358 000 000
278.	River terrace.	11 684 000 000
282.	Triassic red sandstone.	14 736 000 000
238.	Catskill.	14 839 000 000
289.	Shales (Hamilton, &c.)	18 295 000 000
288.	Helderberg limestone.	19 638 000 000
....	Trenton chazy limestone.	24 653 000 000

Table 11 gives the approximate number of grains of sand and clay in one gram of these type subsoils, and the results confirm what has been stated before, that the soils thus arranged are in the order of their relative agricultural value.

The Oriskany formation is of very small agricultural importance, as it has such a small area in the State, occurring in narrow belts, the widest being hardly more than a mile across. It has a place in the table between the tobacco and wheat soils of Southern Maryland.

The Triassic red sandstone and the Catskill formations are shown to have about the same structure. The soils themselves are very similar, and, except for their distinct geological and geographical positions, they should be grouped as a single soil type. The Catskill formation covers a considerable area in the valley between Sideling Hill and Town Hill Mountains, and again between the Great Savage Mountain and the Meadow Mountain, with a very narrow belt near Dan's Mountain, between Mt. Savage and Cumberland, where our single sample of the formation was obtained. This is an important soil formation, which should be more carefully studied, and of which more samples should be taken. From the general appearance of the land, as seen from the train in passing, there does not seem to be as much undecomposed rock in the soils of these wider areas as is contained in the sample, which is given here. I should estimate that there are about 320 square miles of this Catskill formation in Western Maryland, and about the same area of the Triassic red sandstone to the north and south of the Frederick Valley.

The Hamilton and Chemung shales have their widest exposure around Hancock and on either side of the Polish Mountain, covering perhaps 125 square miles. The Clinton and Niagara shales occur in very narrow ridges, giving a much smaller exposure than this. The mechanical analysis of the type sample of these formations gives 39.36 per cent. of "clay," or, approximately, eighteen thousand million grains per gram. The samples contained many small fragments of rock, so far disintegrated that they went to pieces at once between the fingers, or when they were gently rubbed with the rubber pestle under water. As these fragments would so readily fall to pieces in handling, much of this was classed as "fine earth," and only 17.23 per cent. could be separated out as coarse material. I think that this type has not its true agricultural place in the arrangement of these tables, as the grains of sand and clay have evidently not the same arrangement as in a soil where the disintegration has been more complete and the grains are more evenly distributed. It was stated in a previous section that these soils were naturally poor, but had good body and could be improved. This table shows that they have good body, and it remains now to show how the actual conditions differ from the best conditions which should prevail in this type soil, and how the soils can best be improved. In other States, where these shales are more thoroughly decomposed, they make some of the most fertile lands. They should have a value not far below that of the Helderberg limestone.

There is but a small area of the Helderberg limestone in this State, occurring in several narrow belts crossing Western Maryland. The

area of the whole formation is only a few square miles in extent. The formation gives a very fine grass and wheat soil. In the calculations which follow, I have used the Helderberg limestone as the strongest soil, and the best for grass and wheat of any of the types, not having sufficient samples from the Trenton limestone to establish a satisfactory type sample.

I must again urge, as in a former paragraph, that the number of grains of sand and clay give only the skeleton structure of the soil, and that this may be so filled in with organic matter as to greatly modify the physical properties of the soil. The amount of organic matter is assumed to be fairly constant for the different types, and is a matter of more importance in the study of local soils. It is important also to remember that the structure of the soil, and its relation to the circulation of water, is dependent not only upon how many grains there are per gram, but upon how these grains are arranged. In our calculations, we have assumed that they have the same mean arrangement in all the type soils; but this is evidently not so in regard to local soils, for we have suggested that the deterioration of soils is due largely to a change in the arrangement of the soil grains, changing the relation of the soil to the circulation of water. These type samples, however, represent more than this, for they are selected to represent the average, natural condition of these great soil formations.

The average, natural arrangement of the grains in these great soil formations must be determined to give an additional basis of comparison between the different types, but especially for the comparison of local soils, which may have departed, in one way or another, from the type conditions, through a re-arrangement of the grains of sand and clay. This is important in the study and classification of local soils.

It is quite possible to conceive of a brick clay or a tight pipe clay, having no more grains per gram than this Helderberg limestone. If a few drops of caustic ammonia was applied to the Helderberg soil, through which a certain weight of water was passing in a hundred minutes, the grains of soil would be re-arranged, and it would take several thousand minutes for the same amount of water to pass. On the other hand, a little lime water would make the soil more loamy, and hasten the rate of movement of water. We have thus a loam soil, a good clay soil and an impervious pipe clay, out of the same soil, by a simple re-arrangement of the sand and clay. The arrangement of the grains has, therefore, an important bearing on the physical properties of the soil, but this is largely dependent upon local causes, which modify the conditions in the original soil formation.

From the results in these tables it would seem that the subsoil of good grass land would have not less than 30 per cent. of clay, or about *twelve thousand million* grains per gram, and good wheat land not less than twenty per cent., or about *nine thousand million* grains per gram; *provided*, these grains have a certain mean arrangement and

that this skeleton structure contains an average amount of organic matter. It must be remembered that if either the arrangement of the grains or the amount and condition of the organic matter departs from the average condition of the soil, the physical condition of the local soil will depart from the typical conditions of the soil formation.

These type subsoils have the following approximate extent of surface area per cubic foot:

276. Pine barrens.	40 per cent. space.	23 940 square feet.
284. Truck.	45 " " "	74 130 " "
286. Tobacco.	50 " " "	84 850 " "
290. Oriskany.	50 " " "	87 720 " "
280. Wheat.	55 " " "	94 540 " "
278. River terrace.	55 " " "	106 200 " "
282. Triassic.	55 " " "	127 000 " "
288. Helderberg limestone.	65 " " "	129 700 " "
238. Catskill.	55 " " "	133 300 " "
289. Shales (Hamilton, &c.)	60 " " "	142 700 " "

The practical bearing of these results has been quite fully set forth in Section VIII. The Helderberg limestone has a place here before the Catskill and the shales, because we have given it a high percentage of empty space, higher perhaps than should have been given. It has, of course, the highest percentage of surface area per unit weight of any of these subsoils, but the larger amount of space lowers the percentage per unit volume of soil.

From the foregoing results, we have calculated the relative rate with which a given quantity of water would pass through an equal depth of these subsoils, under a constant force and with the same amount of water (12 per cent.) in each subsoil, taking the subsoil of the Helderberg limestone as a basis of comparison.

It would appear from results on next page that, with 12 per cent. of water present in all the subsoils, it will take only 8 minutes for a quantity of water to pass through the subsoil of the pine barrens, which would require 100 minutes to pass through the same depth of the subsoil of the Helderberg limestone. It will pass through the subsoil of the wheat land of the river terraces in Southern Maryland in about 49 minutes. It will move down more readily in these lighter soils from its own weight, but, as I have urged in a previous section, a given quantity of water could not be raised so readily to supply the needs of a growing crop, for there would be less exposed water-surface to contract, that is, there would be less force to pull it up.

No.	Soil.	Space.	Water-content.	Relative Time.
276.	Pine barrens.	40 per cent.	12 per cent.	8
284.	Truck.	45 " "	12 " "	21
286.	Tobacco.	50 " "	12 " "	33
290.	Oriskany.	50 " "	12 " "	35
280.	Wheat.	55 " "	12 " "	45
278.	River terrace.	55 " "	12 " "	49
282.	Triassic.	55 " "	12 " "	56
238.	Catskill.	55 " "	12 " "	58
289.	Shales (Hamilton, &c.)	60 " "	12 " "	81
288.	Helderberg limestone.	65 " "	12 " "	100

I have calculated the amount of water which should be present in these different subsoils for the rate of movement, due to a constant force, to be the same as in the subsoil of the Helderberg limestone, containing 12 per cent. of water.

No.	Soil.	Space.	Water-content.	Relative Time.
276.	Pine barrens.	40 per cent.	5.3 per cent.	101
284.	Truck.	45 " "	7.2 " "	101
286.	Tobacco.	50 " "	8.4 " "	102
290.	Oriskany.	50 " "	8.6 " "	101
280.	Wheat.	55 " "	9.4 " "	100
278.	River terrace.	55 " "	9.6 " "	100
282.	Triassic.	55 " "	10.0 " "	101
238.	Catskill.	55 " "	10.1 " "	100
289.	Shales (Hamilton, &c.)	60 " "	11.2 " "	100
288.	Helderberg limestone.	65 " "	12.0 " "	100

The relation of these different subsoils to water is as different as in the artificial conditions in green house culture. The difference is amply sufficient to account for the distribution of plants and for the known relations of these different soils to plant growth and development.

I have also calculated the relative rate with which water would move, under a constant force, through these different subsoils, if all the space within them was filled with water.

No.	Soil.	Space.	Water-content.	Relative Time.
276.	Pine barrens.	40 per cent.	20.10 per cent. (sat.)	74
284.	Truck.	45 " "	22.41 " " "	141
286.	Tobacco.	50 " "	27.42 " " "	121
290.	Oriskany.	50 " "	27.42 " " "	130
280.	Wheat.	55 " "	31.55 " " "	109
278.	River terrace.	55 " "	31.55 " " "	119
282.	Triassic.	55 " "	31.55 " " "	137
238.	Catskill.	55 " "	31.55 " " "	140
289.	Shales (Hamilton, &c.)	60 " "	36.14 " " "	123
288.	Helderberg limestone.	65 " "	41.22 " " "	100

It will be seen that the amount of space assigned to these different soil formations, has an important bearing on the relative rate with which water will move within the different soils. The coarser textured soils have less space and will contain less water than the clay soils. The subsoil of the truck land has only 45 per cent. of space, and will hold but 22.41 per cent. by weight of water, when this space is completely filled. The subsoil of the Helderberg limestone has 65 per cent. of space, and will hold 41.22 per cent. by weight of water, or nearly twice as much as the truck land. When the soils contained only 12 per cent. of water, a quantity of water would move through the truck land in 21 minutes, which would require 100 minutes to pass through the subsoil of the Helderberg limestone. When, however, these soils are taxed to their utmost, it will take 141 minutes for a quantity of water to pass through the truck land, which would go through the limestone subsoil in 100 minutes. As suggested in a previous section, this undoubtedly explains a matter of common observation and experience, that crops on these light lands are more injured by excessive wet seasons than crops on heavier soils.

These calculations of the relative rate with which water will move within these different subsoils, are based solely upon the skeleton structure. The influence of the organic matter is not considered, and the soil grains are assumed to have the same mean arrangement. These two factors, the amount of organic matter and the arrangement of the soil grains, are probably nearly alike under the normal conditions which prevail in these great soil formations; but if they have not relatively the same effect in the different soils, they will undoubtedly make the difference in the relation of these soils to the circulation of water, still wider than the values we have assigned. Each of these factors requires a distinct line of investigation, and this is necessary to the practical use and application of this work.

REPORT OF THE CHEMIST.

By H. J. Patterson, B. S.

During the past year the chemical department of the Station has been able to do more special work than in previous years, although occupied much of the time, as usual, with the chemical details of the general routine of experiments. In the pages following results are given of the investigations conducted during the year, so far as they have been completed in time for this report.

As heretofore, considerable time has been used in the study of methods of analysis, both individually and in co-operation with the Association of Official Agricultural Chemists.

The special tobacco work conducted by the Station this year required a good deal of my time during the summer and autumn months, in arranging field work and curing-houses and securing samples for the laboratory. Analytical work upon these samples will begin with the new year.

A number of farmers' institutes and other public meetings, including county fairs, have been attended, with lectures and exhibits, to explain the application of chemistry in practical farming, as well as in agricultural experiments.

During the year, 384 samples have been received at the laboratory, these being classified as follows:—Marls and similar substances, 30; Limestones and lime, 5; Muck, 1; Fodders, 157; Fertilizers, 24; Dungs, 68; Urines, 57; Milks, 26; Substances for Ash analysis, 12; Miscellaneous, 4. The examination of these samples, together with the special investigations in progress, involved over 2500 determinations. The necessary records to accompany this work have been kept, and all results prepared for private report and for publication, as appears later.

The meteorological records, as far as kept at the Station, have been, as heretofore, in charge of this division; they are shown by the appended summaries for the year 1891.

Little change has been made in the equipment of the laboratory, during the year. A few special pieces of apparatus have been obtained, but none of them so unusual as to call for any description here.

I.—Marls.

Marls are found in large quantities in many parts of Maryland, and have been used more or less for agricultural purposes for many years. From the small quantity of plant food which marls furnish and the difficulty and expense of handling and transportation, their use is generally confined to places very near the deposits.

Marls may be considered in three classes, according to their general character and the geological formations in which they occur, being only three of the many formations in this State. These formations are found, as a rule, one above the other, but it is rare that more than one occurs in a single exposure. The upper marl, known as shell marl or blue marl, is found in the Neocene or most recent of these three formations, at or very near the surface. It consists chiefly of sea mud, with sand and clay and partially decayed shells and bones. Its value depends mainly on lime, which it contains in the form of the carbonate. This class of marl usually has a very small percent. of phosphoric acid and potash, although sometimes it contains beds of glauconite, which gives a higher potash value. The physical character of these calcareous marls varies with the class of animal remains from which they are derived and the state of preservation of the same. To this class belong most of the marls that have been examined at this Station, as this Neocene formation covers a large area in Southern Maryland.

The second class of marl is found in the Eocene formation which is older than the Neocene, and is just below it in the geological order. It is friable and somewhat chalky, consisting of comminuted shells and corals, and is of a light color. The agricultural value of this variety is given by the potash and the carbonate of lime which it furnishes. The glauconite or green sand may be expected to be found in this class. In parts of New Jersey this is very prominent, but the percentage of potash has been found, as a rule, to be much lower in this State.

The third class, or that which has the lowest geological position is the Cretaceous marl. This also contains glauconite and is commonly

known as "green sand" in New Jersey. There are very few exposures of this formation in Maryland and it is difficult to distinguish it from the Eocene. Marls of this class vary considerably in their chemical composition and agricultural value. They owe their fertilizing quality to the presence of phosphoric acid and potash, and sometimes contain a goodly admixture of calcareous matter. The best New Jersey marls and those that have been used with the most success, have contained from two to three per cent. of phosphoric acid and from five to seven per cent. of potash. The few Maryland marls of this class that have been examined here, thus far, have not given nearly as high a per cent. of these ingredients.

Marls occur in each of these three geological formations in a succession of beds, varying in thickness from a few inches to many feet and separated by layers of gravel, sand or clay. There may be many of these beds of marl in the same formation and several beds of the same class often seen in the same exposure, but the different classes of marl are rarely seen together.

The potash of marls being in an insoluble form must necessarily act very slowly in the soil. With the object of getting some cheap method of converting the potash to a form more available to plants, this Station has now in progress a series of experiments in the composting of marls.

The marls examined during this year have been in greater variety than those received heretofore, and are good types of the deposits in different parts of the State. And this branch of the year's work has more than usual interest and value because most of these samples were carefully selected by Prof. Whitney, Physicist of the Station, during the scientific expedition in May last, along the shores of Chesapeake Bay and the Potomac and Patuxent Rivers. The classification and description of these samples were made by Prof. Whitney. Collectively, the samples included in this report, are believed to represent in character and composition, all the deposits in Maryland which are so exposed as to be accessible for use.

Maryland Marls,—Description of Samples:

Neocene Marls.—Commonly known as shell marl or blue marl. These are generally more abundant or at least they commonly attract more attention than any other class of marls which exist in the State. They are to be found exposed principally in the bluffs, from Herring

Bay around to Pope's Creek on the Potomac River. The Patuxent River and its tributaries, as far North as Upper Marlboro, Prince George's County, the St. Mary's River, the Port Tobacco Creek, and most of the lower tributaries of the Potomac River, cut down into this marl formation.

Eocene Marls.—These are found in the bluffs and river banks from Baltimore, down to West River, again on the Potomac River at Pope's Creek and thence to Washington. Most of the rivers and creeks, within this belt crossing the State, cut down through the overlying materials into these formations, giving inland exposures of the marl deposits. The Eocene marl of the Western Shore has the glauconite predominating, and has but few shells, and is consequently very low in lime and often runs very much higher in potash than the Neocene marls. The Eocene marl of the Eastern Shore is of the friable chalky variety and contains little or no glauconite. In extent and composition the Eocene marls in this State replace the Cretaceous or green sand marls of New Jersey, though they seldom have as high a per cent. of potash.

Cretaceous Marls.—The Eocene and Cretaceous marls of this State cannot be distinguished except by a very careful identification of the shells which they contain. They differ very little in composition and manurial value. There is only a very narrow and irregular belt of Cretaceous marls in this State; and it is exposed at but few places. The Eocene and Cretaceous marls are often found in the same exposures.

Neocene Marls.

Index No. 1021—Shell marl from an exposure one-half mile South of Plum Point. This is probably the finest exposure of shells in Maryland.

No. 1027—From a lower marl bed in the same exposure as 1021.

No. 1022—Sample from upper marl bed at Cove Point, three miles North of Drum Point. The marl has a yellowish green color.

No. 1025—Sample from lower marl bed at Cove Point, three miles North of Drum Point. From under sample 1022.

No. 1026—Shell marl from under lower marl bed at Jones's Wharf, Patuxent River.

Eocene Marls.

No. 879—Green sand marl from deposit on farm of E. L. Nixon, T. B., Prince George's Co., Md.

No. 880—Green sand marl from deposit on farms of Mr. Vick, T. B., Prince George's Co., Md.

No. 1030—Green sand marl, with few or no shells, deposit on farm of T. B. Beall, Davidsonville, Anne Arundel Co., Md.

No. 1167—Green sand marl from farm of Fred. Sasscer, Upper Marlboro. From an exposure in a road cut about one-half mile west of the town.

No. 1147—Green sand marl containing numerous shells, from an exposure on the farm of J. A. Shultz, Seat Pleasant, Prince George's Co., Md.

No. 1028—Green sand marl, containing few shells, from Pope's Creek, directly under the diatomaceous earth, No. 1020.

No. 1024—Green sand marl from a bluff at Potomac Creek, Va. Contains numerous shells.

No. 1079—Green sand marl from Virginia; bank of the Potomac River, three miles North of Mathias Point. Sent by Hammond Hunter, Martinsburg, W. Va.

No. 1105—Shell marl from bank of Port Tobacco Creek, on farm of Miss M. E. Wills, Bel Alton, Md. Six or eight feet below surface. Easy of access.

No. 1106—Shell marl from bank of Port Tobacco Creek, near the mouth. First layer about three feet thick and eight or ten feet below surface, further North along the creek than 1105. Exposure on the farm of Miss M. E. Wills, Bel Alton, Charles Co., Md.

No. 1107—Shell marl; this layer from next below the one from which sample 1106 was taken. Layer three or four feet thick.

No. 1108—Marl from bottom of ravine North of house; on farm of Miss M. E. Wills, Bel Alton, Charles Co., Md.

No. 1029—Shell marl from an exposure one-half mile North of Potomac Creek.

No. 1023—Shell marl from upper marl bed in an exposure at Clifton Beach, on the farm of H. D. Penninger. It has something of a reddish tinge, and was used with great success on the land years ago.

No. 1019—Shell marl from lower marl bed in the same exposure at Clifton Beach as 1023. This does not do so well on land as marl from upper bed.

Cretaceous Marl.

No. 1146—Cretaceous marl from an exposure on the farm of J. A. Shultz, Seat Pleasant, Prince George's Co., Md.

Unclassified Marls and Miscellaneous Materials.

No. 798—Marl taken from near the surface, sent by Geo. Earle, Jr., Millersville, Md.

No. 799—Marl marked "B," taken from near the surface, sent by Geo. Earle, Jr., Millersville, Md.

No. 800—Marl marked "C," taken from near the surface, sent by Geo. Earle, Jr., Millersville, Md.

No. 878—River mud, sent by A. F. Parsons, Salisbury, Md.

No. 1020—Diatomaceous earth from the mine at Pope's Creek. This is not a true marl, but the impure deposit stained with organic matter; it is sometimes applied to land.

No. 1148—Dirt from bottom of a well 20 feet deep, sent by W. O. Reeder, Laurel Grove, Md. Not a marl.

No. 1166—Marl or porous lime rock, 2 feet below the surface; crops out at places. Thickness unknown. Sent by Geo. W. Worman, Frederick, Md.

The table following gives the chemical composition of the marls which have been analyzed, arranged with reference to the characteristic parts of the several samples. The Neocene marls being essentially calcareous and their value depending mainly on the lime they contain, are arranged according to the percentage of this constituent. The Eocene marls being valued chiefly for their potash, are arranged according to their potash content. The average content of lime in this class of samples is low, while two of them have over four per cent. of potash and half the samples have over two per cent. Those having the least potash have the most lime and generally enough to give them some agricultural value:

TABLE. COMPOSITION OF MARYLAND MARLS.

Per centum in Air-dry Substance.

Index No.	Geological Formation and Locality.	Water.	Insoluble* Residue.	Lime.	Potash.	Phosphoric Acid.
	Neocene Marls:—					
1026..	Jones' wharf..................	0.18	46.76	24.55	0.24	0.10
1025..	Cove Point...	0.43	67.24	15.30	1.88	0.06
1027..	Plum Point....................	0.40	71.43	13.70	0.72	0.38
1021..	" "	0.48	73.08	12.45	0.31	0.38
1022..	Cove Point....................	0.45	73.07	12.15	0.33	0.06
	Eocene Marls:—					
1107..	Bel Alton................. ...	2.33	65.51	1.25	4.76	0.26
1106..	" "	1.90	67.68	5.10	4.17	0.29
1167..	Upper Marlboro.............	3.13	75.33	0.45	2.88	0.45
1030..	Davidsonville................	1.43	80.11	0.30	2.71	trace
1019..	Clifton Beach......	1.90	52.93	12.70	2.36	0.20
1028..	Pope's Creek.................	2.17	78.25	trace	2.35	trace
1105..	Bel Alton....................	2.67	66.00	5.90	2.34	0.24
1079..	Mathias Point, Va........ ...	3.17	78.66	trace	1.81	trace
1023..	Clifton Beach................	1.80	59.85	11.45	1.11	0.16
1024..	Potomac Creek, Va...........	1.35	84.52	0.85	1.04	0.08
1147..	Seat Pleasant...........	1.55	50.59	9.10	0.64	0.16
879..	T. B.........................	1.85	86.46	1.25	0.56	0.19
880..	"	0.98	91.65	0.90	0.42	0.41
1029..	Potomac Creek. Va...........	0.70	56.09	17.30	0.33	trace
	Cretaceous Marls:—					
1146..	Seat Pleasant................	1.93	78.11	2.45	0.65	0.18
	Unclassified Marls and Miscellaneous:—					
1166..	....	1.25	8.80	50.10	0.28	0.08
799..	....	0.78	75.39	12.19	0.21	0.48
798..	....	2.78	87.90	1.62	0.38	trace
800..	....	1.52	92.90	1.25	0.16	trace
1020..	Diatomaceous earth...........	....	89.40	trace	....	....
1148..	....	2.70	76.69	trace	1.32	0.29
1108..	.. ..	2.73	80.94	0.85	0.73	0.45
878†..	River Mud....................	9.67	73.05	trace	0.39	0.19

* Composed of sand and silica.

† This sample contains 0.38 per cent. of Nitrogen.

II.—Lime and Lime Stones.

Although lime was probably the first material used on land to increase its fertility, the nature of its action on soils has been but slightly studied and is not yet fully understood. Almost every one recognizes the fact that there is a great difference in the action of lime on soils of different character. And there is a difference between the action of limes of different character on the same soil, although this is a point seldom noticed. But it is a fact that the character of lime has much to do with the success or failure of its application, and it will be necessary to study the question from this standpoint in order to get at the true facts of its action.

The term lime is generally understood to mean quick lime or calcium oxide [CaO]. This is produced by burning limestone in kilns with coal. By the process of burning the limestone or calcium [lime] carbonate undergoes decomposition, carbonic acid [CO_2] being thrown off, and quick lime [Calcium oxide, CaO] remains in the kiln.

It is common to hear the terms "agricultural lime" and "building lime," used as if these were different articles. In reality no such difference exists; they are simply trade terms,—for the same lime is used indiscriminately for these two different purposes. Sometimes, however, the name "agricultural lime" is used to mean building lime that has been air or water slaked, and again it refers to the quality of the stone from which it was derived; if it were always thus used the term would have a distinct meaning.

According to the nature of the limestone, the lime will turn out (*a*) a fat or rich lime, (*b*) a poor lime, or (*c*) an hydraulic lime. If limestone consists simply of pure carbonate of lime, then the lime obtained therefrom will slake readily, forming a creamy mixture with water and is called fat or rich lime. On the other hand if the limestone contains magnesia, it slakes more slowly, forming a thin, poor mixture with water, and is called a poor lime; with ten per cent. (10%) of magnesia a lime is poor, and with 25 to 30 per cent. it is almost useless. If the limestone contains more than 10 per cent. of silica, the lime therefrom will have the quality of forming a paste which will harden under water or in moist places where it is not exposed to the drying influence of the air; such lime is known as hydraulic lime. It is very reasonable to suppose that these various limes act differently on the same soil or on soils of different character

and much in the same manner as they do in forming mortars and cements.

Limestone.—Good limestone contains 50 to 55 per cent. lime [CaO] and 40 to 45 per cent. carbonic acid [CO_2], or 90 to 98 per cent. calcium [lime] carbonate, with small amounts of magnesia, silica, iron and alumina.

Magnesium Limestones or Dolomites—These are quite varied in their composition and may range in carbonate of lime from 20 to 80 per cent., and in carbonate of magnesia from 10 to 60 per cent., with admixtures of silica, iron and alumina.

Oyster Shells.—These contain from 85 to 90 per cent. of calcium [lime] carbonate.

Gas Lime.—The lime from gas-works is often used on land and compared with quick lime. Quick lime is used at the works for removing impurities of the gas. After it has become saturated with the impurities and no longer fit for use in gas-making, it is sold for agricultural purposes under the name of gas lime. This article varies considerably in composition, but consists essentially of the hydrate, carbonate, sulphate and sulphites of lime. The sulphides and sulphites of lime are injurious to germinating seed or young and tender plants, so that gas lime should be applied cautiously and when not too fresh. The action of the air on the sulphides and sulphites change them to sulphate of lime [gypsum or land plaster]; hence, the exposure of gas lime to the weather, for some time, improves its agricultural qualities. Gas lime usually contains about 22 per cent. water, 43 per cent. lime [CaO], 21 per cent. sulphuric acid, 8 per cent. magnesia and 6 per cent. insoluble matter. Of course this will vary considerably according to the character of lime used and the amount and nature of the impurities.

Slaked Lime.—In the process of slaking lime, it takes up water and forms calcium or lime hydrate. It also absorbs some carbonic acid from the air and forms carbonate of lime. If different samples of stone-lime or slaked lime are in equally good condition, they may be thus compared:

Kind of Lime.	Weight per bus. before slaking.	No. of bus. after slaked.	Weight per bus. after slaked.
Good stone-lime..........	93 lbs.	3	45 lbs.
Magnesian stone-lime.....	80 "	2	55 "
Oyster-shell lime.........	60 "	$2\frac{1}{4}$	40 "

During the past year the Station has received and examined several samples of lime and lime-stones from different sections of the State, resulting as follows:

Index No. 802.—*Gray Limestone.*

Gray limestone taken from quarry of M. J. Grove's Lime Co., Lime Kiln, Frederick County, Md.

Composition:—

Calcium carbonate*	93.49	per cent.
Magnesium carbonate†	5.95	"
Oxide of iron and alumina	0.14	"
Insoluble matter, sand, silica, etc	0.41	"
	99.99	"

Index No. 803.—*Blue Limestone.*

Blue limestone taken from same quarry as gray stone, sample No. 802. Sent by M. J. Grove's Lime Co., Lime Kiln, Frederick Co., Md.

Composition:—

Calcium carbonate‡	93.26	per cent.
Magnesium carbonate§	2.50	"
Oxide of iron and alumina	0.36	"
Insoluble matter, sand, silica, etc	3.90	"
	100.02	"

Index No. 1042.—*Pulverized Marble.*

Pulverized limestone taken from quarry at Cockeysville, Balt. Co., Md. Sent by Beaver Dam Marble Co.

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*Equal to 52.36 per cent. lime [CaO.]
†Equal to 2.84 per cent. Magnesia [MgO.]
‡Equal to 52.23 per cent. lime [CaO.]
§ " " 1.19 per cent. magnesia [MgO.]

Composition.

Calcium carbonate*..................	52.33	per cent.
Magnesium carbonate†..............	43.69	"
Oxide of iron and alumina...........	1.55	"
Insoluble matter, sand, silica, &c.....	2.33	"
Moisture........................	0.08	"
	99.98	"

INDEX No. 1043.

Sample stone lime taken at Woodsboro, Frederick Co., Md. Used for agricultural purposes. Sent by W. H. Biggs & Bro., Rocky Ridge, Md.

Composition.

Lime [CaO]........................	91.10	per cent.
Magnesia [MgO]....................	0.92	"
Oxide of iron and alumina...........	3.10	"
Insoluble matter, sand, silica, etc.....	1.85	"
Undetermined, mostly water and [CO_2]	3.03	"
	100.00	"

INDEX No. 1044.

Sample stone-lime taken at Cavetown, Washington Co., Md. Used for agricultural purposes. Sent by W. H. Biggs & Bro., Rocky Ridge, Md.

Composition.

Lime [CaO]........................	73.90	per cent.
Magnesia [MgO]....................	17.94	"
Oxide of iron and alumina...........	4.83	"
Insoluble matter, sand, silica, etc.....	2.75	"
Undetermined, mostly water and [CO_2]	0.58	"
	100.00	"

*Equal to 29.3 percent. lime [CaO.]
†Equal to 20.81 percent. magnesia [MgO.]

III.—Muck.

Muck is a term applied to a mass of decaying vegetable matter or bog earth of vegetable origin. It is valuable from an agricultural standpoint in several ways; it often contains considerable nitrogen, with some potash and phosphoric acid; it is a source of organic matter, and its application to most soils will add much to their mechanical condition and the formation of humates; it is valuable in making up composts and the absorption and retention of matter that would otherwise be lost; and muck which has considerable organic matter in a fairly well preserved condition, is very valuable as bedding or litter for stock. The amount of nitrogen which muck contains, ranges from ¼ percent. to 2½ percent., or, from as much as is contained in average yard manure, to four or five times as much.

In Maryland there are vast areas covered with muck to a greater or less depth, and this might be used to good advantage in many ways on the farm and save much outlay for fertilizer. Some of the muck found in this State is very similar to and of as good quality as that used so extensively in Northern Europe, and shipped to this country, baled for use as bedding in city stables.

During the past year the Station has received but one sample of muck for examination, but this proved to be excellent, both from the amount of plant food it contained, and from the fact that it closely resembled the imported article.

Index No. 801.—Muck.

Sent by Geo. F. Pabst, Leonardtown, St. Mary's Co., Md. Muck covers area of four or five acres and is about four feet deep. Can be cut out with spade, in cubes. Samples as received lost 34 per cent. water in air-drying.

Composition of Air-Dry Samples.

Water	3.13	per cent.
Ash	9.83	"
Organic matter	87.04	"
Phosphoric acid	0.20	"
Potash	0.96	"
Nitrogen	2.24	"

Trials made with this muck proved it to be an excellent absorbent, being able to absorb and hold water equal to its own weight.

IV.—A Comparison of the Digestibility of Corn Silage and Corn Stover in Feeding Rations, and of their Effects upon the Consumption of Albuminoids.

The following experiment was undertaken, having for its primary object a study of the effects of the acids of silage on the consumption of the albuminoids, and as to what part this acid material plays in the utilization of other foods by the animal system.

In this discussion we have used the following terms now generally adopted: "Silage" as meaning the product of the silo; "Ensiling" as the process of putting and preserving green forage in a silo; "Corn Stover" as referring to fodder from corn grown for the grain and which has had the ears removed (sometimes referred to as "Corn Straw"); and "Fodder Corn" as meaning corn grown primarily for the fodder or coarse forage, without any reference to the grain produced, and from which the ears have not been removed.

It is a common practice in medicine to use vegetable acids to cause a decrease in the amount of flesh and to retard or stop flesh formation. These acids are also used sometimes to facilitate digestion. Some investigators have suggested that these acids have certain fuel values closely related to that of the carbohydrates, and that their combustion will save the consumption of other materials.

With these different views of the use of the vegetable acids before us, and the present extensive use of silage (which is always acid to a greater or less degree,) as a feeding material, the questions naturally arise: Do the acids of silage aid or retard digestion? Do they cause an increased consumption of albuminoids and consequently a loss in flesh?

Some experiments have been made bearing on this question in which there have been used the artificial addition of the acids or their salts to the food and feeding it to a dog, rabbit or sheep, or in making artificial digestions in the laboratory. But nothing up to this time has come to my notice in the line already indicated, where silage itself was used and fed to neat cattle. The first experiment in this line, and the one suggesting ours was where acids were added to the food of a dog, in which case it caused an increased consumption of the albuminoids and a loss of flesh. The next experiment that comes

to our notice was that of H. Weiske and E. Flechsig* ; they used a rabbit and sheep and fed, in addition to the ordinary food, the calcium and sodium salts of lactic and acetic acids. Their results varied with the animals and quantities used. With the rabbit, large quantities of lactic or acetic acids, in the form of salts, caused an increased consumption of the albuminoids of the body instead of conserving the albumnoids as the carbohydrates do ; while the addition of small quantities of the lactic salts served to conserve the albuminoids and decrease the albuminoid consumption. The only other experiments in that line which have been noticed are those of A. Stutzer,† on the effects and use of some of the vegetable acids which are found in our food and are know to exist in the stomach, in the artificial digestion of albuminoids. He used lactic, butyric, acetic, malic, tartaric, citric, formic and propionic acids in his work. From the results of his experiments, lactic, malic, tartaric, citric and formic acids were found to have a high value in the artificial digestion of albuminoids. The results with acetic acid were found to be surprisingly low.

For the general plan of this experiment, the supervision of the details while in operation, the analytical data and results, and the discussion of the results, the author is responsible.

The care and supervision in feeding, the weighing of food and water, and the keeping of the records of the same are due, and credit should be given to Mr. Hayward, Agriculturist of the Station.

The object, while feeding, was to give such a grain ration as would keep the animals in a good thriving condition, and to closely resemble a ration in ordinary practice ; also, to allow all the coarse fodder or forage that would be eaten, and all the water the animals would drink. A complete record was kept of the food and water.

It was the aim to keep the animals at all times in a good comfortable condition and as nearly normal as possible. The bedding used was sawdust.

The feeding was divided into periods : In the different periods either the grain ration remained the same, with a change of coarse fodder, (silage and stover being substituted for each other,) or the fodder ration remained constant, changing the grain so as to give a

*In Jour. f. Landw., Vol. 37, pp. 199–234, and Bied Centr., Vol. 19, pp. 31–39.
†Landw. Versuchs-Stationen, Vol. 38, pp. 257–279.

variation in the amount and character of the albuminoids. Each period was divided into two portions:—1st, a preliminary portion which was continued long enough to give the food time to assert itself in the animal system, and to be sure all the food of the previous period had been passed off; 2nd, a digestion portion which lasted for five days of each period, during which time all the dung excreted was collected by attendants, and all the urine collected in rubber bags which were frequently emptied.

All the food was sampled for analysis at the time of weighing out. The grain ration was weighed out for a week at a time, each day's ration being kept separate. The corn stover was weighed out for the whole period at once with each day's ration in a separate bag. The silage was brought fresh from the silo each day and a day's ration weighed out immediately on its arrival. The dung and urine were thoroughly mixed each day and samples taken for analysis. The methods used in the analyses were those of the Association of Official Agricultural Chemists. Where no prescribed method has been adopted by that Association the method employed will be given in the text. For popular explanation of chemical terms, etc., see Bulletin No. 3, pages 35 to 38, of this Station.

Animals Used.—The animals selected for this experiment were four [4] Hereford steers. Two of these ("A" and "B") were a little past two years old and two ("C" and "D") were a little past one year old. The animals were unusually uniform in all respects. The pairs were very closely of an age, very nearly equal in size, weight and shape, and quite similar in general temperament.

The animals were Maryland grown, being bred and raised on the same farm and had been subject to precisely the same conditions as to care, feeding and handling throughout. At the time of starting the experiment they were in fair condition, not fat, but in just such a state of flesh as most feeders like to put up for stall feeding. They proved, however, to be rather too particular as to their food and did not have as good appetites as necessary for animals to do their best or be called "good feeders."

These steers were dividid into two lots: One two years old and one yearling in each lot; this was done so as to eliminate any influence which age might exert. The steers in the same lot were fed on the same kind of food, but differing in quantity.

Food Used.—In this experiment the cattle foods used were corn silage, corn stover [fodder], corn meal, cotton-seed meal, gluten meal, and germ feed.

Corn Silage.—The silage was made from corn grown for this purpose at the Station [for description of growing, yield, etc., see report of the Station Agriculturist for 1890]. The silage was in very good condition and could be considered an average representative of this class of feed.

Corn Stover [fodder].—This was the topped fodder from the rotation plots. It was in good bright condition, and not having been exposed long to the influence of the weather after cutting, was probably better than much that is fed in this State. It would have been preferable to have had the fodder grown exactly like that which was ensiled; but this was impossible at this time and it was believed that the difference in this material would not materially affect the results; at the same time it might have a more practical bearing, as representing materials commonly used by farmers.

Corn Meal.—This was white meal made from clean shelled corn, and such as is commonly found in the markets of this section. It was ground quite fine and seemed very nice, but proved upon analysis to be rather below the average of corn meal in the amount of fat it contained.

Cotton-seed Meal.—This was of very good grade, quite free from lint and hulls, of a good bright color and pleasant in odor and taste.

Gluten Meal.—This is a refuse in the manufacture of glucose sugar from corn, and is that portion which remains after washing out the starch from the ground grain. It is of a yellowish-brown color, a little darker than good cotton-seed meal; dry and granular in appearance, and very uniform in character. This particular lot was bought of the Charles Pope Glucose Co., Geneva, Illinois.

Germ Feed.—This is also a waste product in the manufacture of glucose sugar from corn, and consists of the hearts or germs of the kernels, together with the outer hull or bran of the corn. This material is generally fed near the factory, and is not dried out after its first wetting. The material we had was kiln dried. It is grouud rather coarsely and being extremely dry, it was harsh and unpalatable. If it was ground finer, it would add much to its palatability and make a very desirable food.

Digestibility of Rations Used.—Before considering the effects of the acids on the consumption of albuminoids, we will take the question of digestibility,—treating each lot of steers separately throughout the different periods.

It was desired to have the steers eat all they would take, and the feed was increased and decreased somewhat during the preliminary period. The totals of food eaten and the daily averages are given in Table No. 1. This table shows that there was a decided decrease in the amount of stover eaten during the digestion week. This was due, to some extent, no doubt, to the constant presence of the attendant, but more can be attributed to the steers becoming tired of the dry food. The animals had free access to salt at all times and the water of this place is high in the amount of total solids.

The excrement collected as already described, not including the urine, was during this period in quantity as follows:—

TABLE II.—FRESH DUNG EXCRETED PER DAY.—PERIOD I.

In Grams and Pounds [453.6 grams =1 pound.] *Steers A. & C.*

1891.	FEB. 3d.	4th.	5th.	6th.	7th.	Total.
STEER A—						
Grams.........	13,792	7,371	9,100	11,198	9,667	51,129
Pounds........	30.4	16.2	20.0	24.6	21.3	112½
STEER C—						
Grams.........	5,471	6,039	8,477	6,832	5,386	32,205
Pounds........	12.06	13.3	18.6	15.1	11.8	70¾

The samples of the feeding materials and of the excrements, after coming to the laboratory, were dried in an oven heated by steam and then exposed for several days to the air of the laboratory to acquire an amount of moisture about normal. In this condition they were analyzed and the results calculated to the amount of moisture which they contained, when originally sampled. These results are given in Table No. III.

By combining the data in Tables I, II and III, the relative portions of the different components of the food which was digested, have been obtained and are shown by Table IV.

TABLE No. I.—RATION EATEN BY STEERS A. AND C. DURING PERIOD I.

Steer.	Age of Steers.	Portion of Period I.	No. of days.	Stover eaten. Total.	Stover eaten. Average per day.	Corn-meal eaten. Total.	Corn-meal eaten. Average per day.	C. s. m. eaten. Total.	C. s. m. eaten. Average per day.	Water drunk. Total.	Water drunk. Average per day.
				Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.
A....	2 yrs.	Preliminary.....	19	109—1	5—12	135—9	7—2	68—5	3—10	705—0	37—2
		Digestion.......	5	14—10	2—15	40—0	8—0	20—0	4—0	149—0	29—13
C.....	1 "	Preliminary.....	19	81—2	4—4	95—0	5—0	57—0	3—0	434—0	22—13
		Digestion.......	5	8—15	1—13	24—6	4—14	14—10	2—15	93—0	18—9

TABLE No. III.—COMPOSITION OF FOOD EATEN AND REFUSED AND OF DUNG EXCRETED.

PERIOD I.—STEERS A. AND C.

Index No.	Description of Sample.	Water Per Ct.	Dry Subs.	Ash.	Protein.	Crude Fibre.	N. Free Extct.	Fat.	Total Nitgn.	Alb. N.
808	Corn stover (fodder)...................	8.64	91.36	4.98	7.23	29.33	45.94	3.88	1.16	0.84
823	Corn meal...........................	13.65	86.35	0.65	7.70	0.78	74.96	2.26	1.23	....
824	Cotton-seed meal.....................	7.00	93.00	6.35	43.58	8.11	23.08	11.88	6.98	....
881	Corn fodder refused by Steer A..........	7.60	92.40	6.08	7.78	29.75	45.30	3.49	1.25	0.73
882	Corn fodder refused by Steer C.........	7.30	92 70	5.83	6.48	28 99	47.79	3.61	1.04	0.83
	Dung,—Steer A.—Average* of 5 samples.	82.47	17.53	2.18	3.41	3.60	7.61	0.73	0.546	....
	Dung,—Steer C.—Average* of 5 samples.	81.73	18.27	2.24	4.15	3.54	7.69	0.65	0.665	....

*Averages made up in proportion to the amounts of dung excreted per day; each day's samples were treated separately, and complete analyses made throughout. The same is true of all samples of dung in this experiment.

Table IV.—Digestibility,—Period I.—Steers A. and C.

(This Data derived from preceding Tables.)

	Fresh Substance.	Dry Substance.	Ash.	Protein.	Crude Fibre.	N. free Extract.	Fat.	Total Nitrogen.
Steer A.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
Fodder offered..........	18144.0	16576.38	1124.93	1311.79	5321.64	8114.03	703.99	209.87
Fodder refused..........	11510.1	10635.33	699.81	895.49	3424.25	5214.08	401.70	143.28
Fodder eaten	6633.9	5941.05	425.12	416.30	1897.39	2899.95	302.29	66 59
Corn-meal eaten.........	18144.0	15667.34	177.81	1397.09	141.52	13540.87	410.05	223.53
Cotton-seed meal eaten...	9072.0	8436.96	576.08	3953.57	735.74	2093.82	1077.75	632.57
Total eaten.......	33849.9	30045.45	1179.01	5766.96	2774.65	18534.64	1790.09	922.69
Total excreted.....	51129.1	8960.80	1114.61	1744.69	1838.79	3888.98	373.73	279.16
Digested...	....	21084.65	64.40	4022.27	935.86	14645.66	1416.36	613.53
Per cent. digested	....	70.14	5.46	69.74	33.73	73.62	79.12	69.74
Steer C.								
Fodder offered..........	13608.0	12432.27	822.28	983.85	3991.21	6106.94	527.99	157.48
Fodder refused..........	9554.0	8856.56	557.00	619.11	2769.70	4565.85	344.90	99.06
Fodder eaten...........	4054.0	3575.71	265.28	364.74	1221.51	1541.09	183.09	58.42
Corn-meal eaten...	11056.5	9547.29	108.35	851.35	86.24	8251.47	249.88	135.99
Cotton-seed meal eaten...	6633.9	6169.53	421.25	2891.06	538.01	1531.10	788.11	463.05
Total eaten.............	21744.4	19292.53	794.88	4107.15	1845.76	11323.66	1221.08	657.46
Total excreted..........	32205.4	5884.90	721.40	1338.36	1141.12	2475.19	208.83	214.15
Digested................		13407.63	73.48	2768.79	704.64	8848.47	1012.25	443.31
Per cent. digested..	....	69.49	9.24	67.41	38.17	78.16	82.89	67.41

TABLE V.—WEIGHTS OF STEERS A. AND C. IN POUNDS,—DURING PERIODS I. AND II.

PERIOD I. DATE 1891.	STEER A.		STEER C.	
	Before Watering.	After Watering.	Before Watering.	After Watering.
Jan. 15	957	960	572	572
" 19	911	949	545	567
" 26	924	966	566	576
Feb. 2	936	986	566	589
" 3	926	947	560	579
" 4	918	958	560	578
" 5	925	950	559	577
" 6	924	957	552	573
" 7	924	954	553	570
" 8	....	940	....	570
Average	927	956	559	575
Greatest variation	46	39	27	13

PERIOD II. DATE 1891.	STEER A.		STEER C.	
	Before Watering.	After Watering.	Before Watering.	After Watering.
Feb. 16	971	1,002	585	589
" 23	966	1,005	587	606
" 24	977	1,003	591	601
" 25	968	1,001	581	601
" 26	974	997	578	596
" 27	976	995	583	598
" 28	950	997	585	594
March 1	979	1,000	587	606
Average	970	1,000	584	599
Greatest variation	29	4	10	17

The animals were weighed daily at noon, during the digestion weeks, both before and after watering, and several times during the preliminary intervals. The weights recorded for the steers A and C for Periods I and II are given in Table V.

Digestibility of Steers A. and C.—Period II:—Period I. was followed immediately by period II. The grain ration remained the same, both in quantity and quality, while corn silage was substituted for corn stover.

The silage was sampled frequently during the preliminary period, and daily during the digestion week. 1,300 grams of the fresh materials were taken each day for the sample and air-dried in the laboratory. The results of loss in air-drying were as follows:

PRELIMINARY,—*February 9 to 14, inclusive.*

Average of 7 samples, 79.65 per cent.; range, 78.48 to 81.12.

DIGESTION WEEK,—*February 23 to 28, inclusive.*

Average of 6 samples, 81.72 per cent.; range, 80.04 to 82.81.

The air-dry samples for the preliminary and digestion weeks, after drying in the oven, were allowed to stand for several days in the ordinary atmosphere of the laboratory, so that they might be assumed to have contained practically the same percentages of hygroscopic or air-dry moisture. These samples were united separately, the whole run through the mill once and thoroughly mixed, and the samples taken of these mixtures for analysis. The results of the analysis for the preliminary period, being the same as that for the digestion week of Period I., of steers B. and D., will be found in Table XIV, and that for the digestion week in Table VIII.

The silage that was refused was weighed back each day and sampled, and the samples were analyzed, but on comparison of the analysis of the water-free substance with the same portion of the original samples, so close an agreement was found that this requires no further attention.

The weights of the animals during this Period have been already recorded in Table V., on the opposite page.

The Tables VI., VII. and VIII. being similar to those for the preceding Period, need no explanation. It may be noted that the quantities of food consumed daily was very uniform throughout Period II. Table IX. was compiled from those immediately preceding.

Table VI.—Food Eaten by Steers A. and C.—Period II.

Steer No.	Age of Steers.	Portion of Period II.	No. of. days.	Silage eaten. Total.	Silage eaten. Average per day.	Corn-meal eaten. Total.	Corn-meal eaten. Average per day	C. s. m. eaten. Total.	C. s. m. eaten. Average per day.	Water Drunk. Total.	Water Drunk. Average per day.
				Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.
A ...	2 yrs..	Preliminary......	15	380— 9	25— 6	120— 0	8— 0	60— 0	4— 0	447— 0	29—13
		Digestion........	5	120— 2	24— 0	40— 0	8— 0	20— 0	4— 0	148— 0	29—10
C ...	1 yr..	Preliminary......	15	222—11	14—14	73— 2	4—14	43—14	2—15	295— 0	19—11
		Digestion	5	72—13	14— 9	25— 0	5— 0	15— 0	3— 0	80— 0	16— 0

Table VII.—Fresh Dung Excreted Daily in Period II.—In Grams and Pounds.

1891.		Feb. 23d.	24th.	25th.	26th.	27th.	Total.
Steer A	Grams....................	13,466	9,157	10,574	10,121	11,283	54,602
	Lbs	29.6	20.1	23.3	22.3	24.8	120.1
Steer C.	Grams....................	8,108	6,747	7,343	7,172	7,825	37,195
	Lbs	17.7	14.8	11.7	15.8	17.2	77.2

Table VIII.—Composition of Food Eaten and Dung Excreted.—Period II.—Steers A. and C.

Index No.	Description of Sample.	Water.	Dry Subs.	Ash.	Protein.	Crude Fibre.	N. free Extct.	Fat.	Total Nitgn.	Alb. Nitgn.
943	Corn silage............................	82.85	17.15	1.37	2.17	5.23	7.36	1.02	0.347	0.186
886	Corn meal..............................	13.30	86.70	1.30	7.96	0.63	74.39	2.42	1.26	....
885	Cotton-seed meal...	6.75	93.25	6.40	45.41	5.88	22.15	13.41	7.27	....
	Dung,—Steer A.	82.40	17.60	2.82	3.91	3.64	6.62	0.61	0.625	....
	Dung,—Steer C..........................	84.71	15.29	1.70	3.81	2.92	5.97	0.89	0.610	....

TABLE IX.—DIGESTIBILITY,—PERIOD II.—STEERS A. AND C.

	Fresh Substance.	Dry Substance.	Ash.	Protein.	Crude Fibre.	N. free Extract.	Fat.	Total Nitgn.
Steer A.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
Silage eaten	54488.7	9344.80	746.49	1182.40	2849.76	4010.37	555.78	189.07
Corn-meal eaten	18144.0	15730.85	235.87	1444.26	114.31	13497.32	439.09	228.61
Cotton-seed meal eaten	9072.0	8459.64	580.61	4119.59	533.43	2009.45	1216.56	659.53
Total eaten	81704.7	33535.49	1562.97	6746.25	3497.50	19517.14	2211.43	1077.21
Total excreted	54601.9	9606.53	1539.65	2133.35	1985.05	3613.39	335.09	341.34
Digested	....	23928.96	23.32	4612.90	1512.45	15903.75	1876.34	735.87
Per cent. digested	....	71.35	1.49	68.22	43.55	81.48	84.84	68.22
Steer C.								
Silage eaten	33027.7	5664.25	452.48	716.70	1727.35	2430.84	336.88	114.61
Corn-meal eaten	11340.0	9831.78	147.42	902.66	71.44	8435.83	274.43	142.88
Cotton-seed meal eaten	6804.0	6344.73	435.46	3089.70	400.07	1507.08	912.42	494.65
Total eaten	51171.7	21840.76	1035.36	4709.06	2198.86	12373.75	1523.73	752.14
Total excreted	37195.0	5687.76	631.66	1417.83	1084.59	2221.12	332.56	226.85
Digested	....	16153.00	403.70	3291.23	1114.27	10152.63	1191.17	525.29
Per cent. digested	....	73.95	38.99	69.89	51.13	82.04	78.17	69.89

TABLE X.—RECORD FOR PERIOD III. OF THE STEER "A."

1ST:—THE FOOD AND WATER CONSUMED.

PORTION OF PERIOD III.	NO. OF DAYS.	SILAGE EATEN.		CORN-MEAL EATEN.		WATER DRUNK.	
		Total.	Average per day.	Total.	Average per day.	Total.	Average per day.
		Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.
Preliminary	9	268—11	29—14	89—12	9—15	141— 0	15—11
Digestion........................	6	129—14	25—15	44— 5	8—14	57— 0	11— 6

2ND:—COMPOSITION OF THE FOOD AND DUNG.

INDEX No.	DESCRIPTION OF SAMPLE.	WATER.	DRY SUBSTANCE.	ASH.	PROTEIN.	CRUDE FIBRE.	N. FREE EXTRACT.	FAT.	TOTAL NITROGEN.	ALB. N.
945	Corn-meal.............	12.30	87.70	1.00	7.96	0.84	75.57	2.33	1.26	....
991	Corn silage.....	81.67	18.33	1.33	2.16	5.68	8.15	1.01	0.345	0.192
	Dung...........	84.31	15.69	1.85	2.88	3.18	7.16	0.62	0.461	....

3RD:—COMPUTATION OF THE DIGESTIBILITY OF THE FOOD.

	FRESH SUBSTANCE.	DRY SUBSTANCE.	ASH.	PROTEIN.	CRUDE FIBRE.	N. FREE EXTRACT.	FAT.	TOTAL NITROGEN.
STEER A.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
Silage eaten	58911.3	10798.44	783.52	1272.48	3346.16	4801.27	595.01	203.24
Corn-meal eaten.........	20100.1	17627.79	201.00	1599.97	168.84	15189.65	468.33	253.26
Total eaten.........	79011.4	28426.23	984.52	2872.45	3515.00	19990.92	1063.34	456.50
Total excreted...........	44314.9	6952.65	819.05	1275.82	1111.16	3171.30	275.32	204.14
Digested................	....	21463.58	165.47	1596 63	2103.84	16819.62	788.02	252.36
Per cent. digested..	....	75.50	16.81	55.59	59.85	84.13	74.11	55.59

Digestibility,—Steer A.—Period III.—During this period only one steer could be used, as Steer C. scoured so badly that reliable results could not be obtained with him and his food had to be changed.

The feed for this period consisted simply of corn meal and silage. The silage samples were taken daily during the digestion period (March 9th to 14th,) and had exactly the same treatment as described in the preceding period. Upon air-drying, the six silage samples were found to have lost an average of 80.62 per cent.—the range being 78.94 to 82.39.

This steer "A." was weighed daily from March 9th to 15th, inclusive, before watering and again afterwards; the average of the seven weighings, before watering, was 982 lbs., and after watering, 990 lbs. The greatest variation between two successive weighings was 22 lbs. The record of dung excreted is omitted.

Table X., on the opposite page gives the record, for this Period, of the food eaten, the composition of food and dung, and the computation of the digestibility of the different components of the food.

Digestibility,—Steers B. and D.,—Periods I., II. and III.—For the sake of an additional check on the subject in question, steers B. and D. were fed on a different grain ration, and had the order of the silage and stover rations reversed from what it was with steers A. and C. This eliminated any errors that might have been involved by the order of feeding, the condition of the weather and grain characteristics.

With these steers the grain ration was gluten meal and germ feed, and the silage was fed during the first period, with stover during the second and third periods. But for the third period, wheat bran was substituted for the germ feed, for two reasons:—1st, to have a different source of albuminoid food; and 2d, to secure about the same amount of nitrogen, with a decided reduction in the vegetable fats. (This last point is considered later.)

In all other respects the procedure was the same as during the like periods for the other steers, already described. The record may therefore be condensed and presented as follows, without further comment. See Tables No. XI. to XIX., inclusive.

The silage samples, upon being air-dried, showed these losses in weight:—January 28th, preliminary, 81.14 per cent.; February 8th to 14th, digestion week, seven (7) samples lost an average of 79.65 per cent., the range being 78.48 to 81.12.

TABLE XI.—FOOD EATEN BY STEERS B. AND D.—PERIODS I., II. AND III.

Steer.	Age of Steers.	Portion of Period I.	No. of days.	Silage eaten.		Gluten meal.		Germ feed.		Water drunk.	
				Total.	Daily Av.	Total.	Daily Av.	Total.	Daily Av.	Total.	Daily Av.
				Lbs. oz.	Lbs. oz.	Lbs. oz	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.
B	2 yrs..	Preliminary......	26	382—12	14—12	114— 8	4— 6	89—12	3—7	487—0	18— 8
		Digestion...	5	93— 5	18—10	14—10	2—15	10—15	2—3	70—0	14— 0
D ...	1 yr..	Preliminary......	26	391— 2	15— 1	57— 7	2— 3	38—15	1—8	284—0	10—15
		Digestion.... ...	5	66—14	13— 6	15— 0	3— 0	10— 0	2—0	48—0	9—10

Steer.	Age of Steers.	Period II.	No. of days.	Stover eaten.		Gluten meal.		Germ feed.		Water drunk.	
				Total.	Daily Av.	Total.	Daily Av.	Total.	Daily Av.	Total.	Daily Av.
B	2 yrs..	Preliminary.	15	94— 2	6— 4	49—2	3—4	36—13	2— 7	583—0	38—14
		Digestion...	5	33— 8	6—11	15—5	3—1	11— 7	2— 5	173—0	34—10
D	1 yr...	Preliminary......	15	56— 6	3—12	36—3	2—7	24— 2	1—10	343—0	22—14
		Digestion........	5	20—11	4— 2	15—0	3—0	10— 0	2— 0	133—0	26— 0

Steer.	Age of Steers.	Period III.	No. of days.	Stover eaten.		Gluten meal.		Wheat bran.		Water drunk.	
				Total.	Daily Av.	Total.	Daily Av.	Total.	Daily Av.	Total.	Daily Av.
B	2 yrs..	Preliminary......	15	114—12	7—10	60—0	4—0	60—0	4—0	581—0	38—12
		Digestion........	5	39— 9	7—14	20—0	4—0	20—0	4—0	203—0	40—10
D	1 yr...	Preliminary......	15	88—11	5—15	30—0	2—0	30—0	2—0	389—0	25—15
		Digestion.......	5	26—13	5— 6	10—0	2—0	10—0	2—0	126—0	25— 3

Table XII.—Fresh Dung Excreted Daily.

In Pounds and Grams.

Period I.

1891.	Steer B.		Steer D.	
	Lbs.	Grams.	Lbs.	Grams.
Feb. 10	15.8	7172	12.6	5727
" 11	17.5	7995	12.5	5698
" 12	18.6	8477	12.0	5471
" 13	16.3	7428	16.9	7683
" 14	16.1	7314	13.0	5897
Totals	84.3	38386	67.0	30476

Period II.

1891.	Steer B.		Steer D.	
	Lbs.	Grams.	Lbs.	Grams.
March 3	26.3	11964	15.7	7144
" 4	24.2	11014	17.5	7966
" 5	26.6	12105	18.6	8448
" 6	32.2	14629	20.8	9469
" 7	28.7	13041	21.9	9979
Totals	138.0	62753	94.5	43006

Period III.

1891.	Steer B.		Steer D.	
	Lbs.	Grams.	Lbs.	Grams.
March 24	29.4	13381	17.8	8079
" 25	28.1	12757	18.5	8392
" 26	28.3	12871	19.6	8902
" 27	31.7	14402	19.1	8704
" 28	29.0	13197	19.5	8930
Totals	146.5	66608	94.5	43007

TABLE XIII.—WEIGHTS OF STEERS,—PERIODS I., II. AND III.

Period I. 1891.	Steer B.		Steer D.	
	Before Water.	After Water.	Before Water.	After Water.
	Lbs.	Lbs.	Lbs.	Lbs.
Jan. 15	970	986	550	591
" 19	950	958	573	573
" 26	975	1000	567	567
Feb. 2	921	967	570	588
" 9	943	965	577	590
" 10	954	964	573	573
" 11	942	952	560	576
" 12	935	963	566	579
" 13	935	938	563	572
" 14	916	935	555	565
" 15	923	932	552	573
Averages	942	960	564	577

Period II. 1891.	Steer B.		Steer D.	
	Before Water.	After Water.	Before Water.	After Water.
Feb. 23	966	991	562	571
March 2	977	1001	567	585
" 3	971	1003	563	584
" 4	965	1004	561	587
" 5	971	1010	564	589
" 6	962	990	561	592
" 7	947	982	550	580
" 8	951	984	554	585
Averages	963	995	560	584

Period III. 1891.	Steer B.		Steer D.	
	Before Water.	After Water.	Before Water.	After Water.
March 16	949	1012	569	610
" 23	971	1016	602	625
" 24	970	1024	599	627
" 25	978	1020	597	626
" 26	980	1019	597	620
" 27	968	1011	594	607
" 28	968	1008	583	616
" 29	962	....	591	619
Averages	968	1015	591	619

TABLE XIV.—COMPOSITION OF FOOD EATEN AND OF DUNG EXCRETED.—PERIOD I.—STEERS B. AND D.

Index No.	Description of Sample.	Watr.	Dry Substance.	Ash.	Protein.	Crude Fibre.	N. free Extract.	Fat.	Total Ninrogen.	Alb. N.
820	Corn silage,—prelim'y..	82.11	17.89	1.87	2.26	5.26	7.71	0.79	0.360	0.245
901	Corn silage........	81.20	18.80	1.33	2.62	5.63	8.16	1.06	0.419	0.271
846	Gluten meal............	6.25	93.75	0.85	35.62	2.03	37.96	17.29	5.70	....
847	Germ feed.............	6.00	94.00	0.90	9.88	11.49	56.10	15.63	1.58	....
	Dung,—Steer B.........	82.96	17.04	1.60	3.07	3.79	7.78	0.79	0.492	....
	Dung —Steer D.........	83.46	16.54	1.55	3.23	3.29	7.37	1.10	0.518	....

TABLE XV.—DIGESTIBILITY,—PERIOD I.—STEERS B. AND D.

	Fresh Substance.	Dry Substance.	Ash.	Protein.	Crude Fibre.	N. free Extract.	Fat.	Total Nitrogen.
STEER B.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
Silage eaten............	42326.5	7957.38	562.94	1108.96	2382.98	3453.84	418.66	177.35
Gluten meal eaten.......	6633.9	6219.28	56.39	2362.99	134.67	2518.23	1147.00	378.13
Germ feed eaten.........	4961.2	4663.53	44.65	490.17	570.04	2783.23	775.44	78.39
Total eaten.............	53921.6	18840.19	663.98	3962.12	3087.69	8755.30	2371.10	633.87
Total excreted,..........	38385.8	6537.86	615.17	1180.50	1454.97	2984.91	302.31	188.86
Digested................	....	12302.33	48.81	2781.62	1632.72	5770.39	2068.79	445.01
Per cent. digested.,......	....	65.30	7.35	71.84	52.88	65.91	87.25	71.84
STEER D.								
Silage eaten.............	30334.5	5702.89	403.45	794.76	1707.83	2475.30	321.55	127.10
Gluten meal eaten.......	6804.0	6378.75	57.83	2423.59	138.12	2582.80	1176.41	387.83
Germ feed eaten.........	4536.0	4263.84	40.82	448.16	521.19	2544.69	708.98	71.67
Total eaten	41674.5	16345.48	502.10	3666.51	2367.14	7602.79	2206.94	586.60
Total excreted.........	30476.1	5042.44	471.22	986.24	1002.48	2246 29	336.21	157.80
Digested............ ...	....	11303.04	30.88	2680.27	1364.66	5356.50	1870.73	428.80
Per cent. digested.......	....	69.15	6.15	73.11	57.65	70.46	84.76	73.11

TABLE XVI.—COMPOSITION OF FOOD EATEN AND OF DUNG EXCRETED.—PERIOD II.—STEERS B. AND D.

Index No.	Description of Sample.	Water.	Dry Substance.	Ash.	Protein	Crude Fibre.	N. free Extract.	Fat.	Total Nitrogen.	Alb. N.
865	Corn fodder (stover)....	7.82	92.18	6.27	6.88	28.94	46.27	3.82	1.10	0.71
921	Gluten meal............	6.60	93.40	0.80	37.80	2.31	35.42	17.07	6.05	....
920	Germ feed..............	6.00	94.00	1.27	10 45	10.18	56.32	15.78	1.68	....
	Dung,—Steer B.... ...	82.30	17.70	1.62	2.06	4.55	8.69	0.78	0.329	....
	Dung,—Steer D.........	83.12	16.88	1.60	2.28	3.88	8.17	0.95	0.366	....

TABLE XVII.—DIGESTIBILITY,—STEERS B. AND D.—PERIOD II.

	Fresh Substance.	Dry Substance.	Ash.	Protein.	Crude Fibre.	N. free Extract.	Fat.	Total Nitrogen.
STEER B.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
Fodder eaten............	15195.6	14007.30	952.76	1045.46	4397.61	7031.00	580.47	167.15
Gluten meal eaten.......	6945.7	6487.28	55.56	2625.47	160.45	2460.17	1185.63	420.21
Germ feed eaten.........	5188.0	4876.72	65.89	542.14	528.14	2921.88	818.67	87.16
Total eaten.............	27329.3	25371.30	1074.21	4213.07	5086.20	12413.05	2584.77	674.52
Total excreted..........	62752.7	11103.53	1014.02	1291.78	2858.20	5452.63	486.90	206.68
Digested................	....	14267.77	60.19	2921.29	2228.00	6960.42	2097.87	467.84
Per cent. digested.......	....	56.24	5.60	69.34	43.81	55.94	81.16	69.34
STEER D.								
Fodder eaten............	9383.8	8649.99	588.36	645.61	2715.67	4341.89	358.46	103.22
Gluten meal eaten.......	6804.0	6354.94	54.43	2571.91	157.17	2409.98	1161.44	411.64
Germ feed eaten.........	4536.0	4263.84	57.61	474.01	461.77	2554.67	715.78	76.20
Total eaten.............	20723.8	19268.77	700.40	3691.53	3334.61	9306.54	2235.68	591.06
Total excreted..........	43006.9	7266.30	688.11	982.56	1670.07	3517.02	408.54	157.21
Digested..	....	12002.47	22.29	2708.97	1664.54	5789.52	1827.14	433.85
Per cent. digested.......	.. ..	62.32	3.18	73.39	49.92	62.21	81.72	73.39

TABLE XVIII.—COMPOSITION OF FOOD EATEN AND OF DUNG EXCRETED.—PERIOD III—STEERS B. AND D.

Index No.	Description of Sample.	Water.	Dry Substance.	Ash.	Protein.	Crude Fibre.	N. free Extract.	Fat.	Total Nitrogen.	Alb. N.
930	Corn fodder (Stover)....	6.47	93.53	7.03	7.10	28.91	46.64	3.85	1.138	0.832
966	Gluten meal.......	6.60	93.40	1.15	37.80	2.40	35.18	16.87	6.05	....
967	Wheat bran...........	10.60	89.40	4.45	16.63	8.53	53.64	6.15	2.65	....
	Dung,—Steer B.........	83.87	16.13	1.19	2.16	3.71	7.83	0.53	0.346	....
	Dung,—Steer D.........	84.05	15.95	1.80	1.90	4.03	7.76	0.45	0.304	....

TABLE XIX.—DIGESTIBILITY,—PERIOD III.—STEERS B. AND D.

	Fresh Substance.	Dry Substance.	Ash.	Protein.	Crude Fibre.	N. free Extract.	Fat.	Total Nitrogen.
STEER B.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
Fodder eaten............	17945.5	16784.43	1261.57	1274.13	5188.05	8369.78	690.90	204.22
Gluten meal eaten.......	9072.0	8473.25	104.33	3429.22	217.73	3191.53	1530.44	548.86
Wheat bran eaten.......	9072.0	8110.37	403.71	1508.67	773.84	4866.22	557.93	240.41
Total eaten.............	36089.5	33368.05	1769.61	6212.02	6179.62	16427.53	2779.27	993.49
Total excreted.	66608.3	10739.40	1261.88	1440.61	2470.81	5212.32	353.78	230.49
Digested........	....	22628.65	507.73	4771.41	3708.81	11215.21	2425.49	763.00
Per cent. digested........	....	67.82	28.69	76.82	60.02	68.27	87.27	76.82
STEER D.								
Fodder eaten............	12162.1	11375.21	855.00	863.51	3516.06	5672.40	468.24	138.40
Gluten meal eaten.......	4536.0	4236.62	52.16	1714.61	108.86	1595.77	765.22	274.43
Wheat bran eaten.......	4536.0	4055.18	201.85	754.34	386.92	2433.11	278.96	120.20
Total eaten.............	21234.1	19667.01	1109.01	3332.46	4011.84	9701.28	1512.42	533.03
Total excreted..........	43006.8	6860.91	776.93	815.80	1732.07	3342.86	193.95	130.52
Digested	....	12806.10	332.08	2516.66	2279.77	6358.42	1317.47	402.51
Per cent. digested........	....	65.11	29.94	75.52	56.83	65.54	87.11	75.52

TABLE XX.—SUMMARY OF RESULTS. THREE DIGESTION PERIODS.
Comparison of the Percentages Digested by the Different Steers.

	Dry Matter.	Ash.	Protein.	Crude Fibre.	N. free Extract.	Fat.	Total Nitrogen.
SILAGE AND GRAIN RATION:							
Steer A.—period II	71.35	1.49	68.23	43.55	81.48	84.84	68.23
Steer C.—period II	73.95	38.99	69.89	51.13	82.04	78.17	69.89
Average for period II	72.70	20.24	69.06	47.34	81.76	81.50	69.06
Steer A.—period III	75.50	16.81	55.59	59.85	84.13	74.11	55.59
Steer B.—period I	65.30	7.35	71.84	52.88	65.91	87.25	71.84
Steer D.—period I	69.15	6.15	73.11	57.65	70.46	84.76	73.11
Average steers B. and D.—period I.	67.22	6.75	72.48	55.26	68.19	86.00	72.48
Average for all silage rations	71.85	14.16	67.73	53.01	76.88	81.83	67.73
Average for periods I. and II	69.94	13.49	70.77	51.30	75.06	83.75	70.77
CORN STOVER AND GRAIN RATION:							
Steer A.—period I	70.14	5.46	69.74	33.73	73.62	79.12	69.74
Steer C.—period I	69.49	9.24	67.41	38.17	78.16	82.89	67.41
Average steers A. and C.—period I.	69.82	7.35	68.58	35.95	75.89	81.00	68.58
Steer B.—period II	56.24	5.60	69.34	43.81	55.94	81.16	69.34
Steer D.—period II	62.32	3.18	73.39	49.92	62.21	81.72	73.39
Average steers B. and D.—period II.	59.28	4.39	71.36	46.87	59.07	81.44	71.36
Steer B.—period III	67.82	28.69	76.82	60.02	68.27	87.27	76.82
Steer D.—period III	65.11	29.94	75.52	56.83	65.54	87.11	75.52
Average steers B. and D.--period III.	66.47	29.31	76.17	58.43	67.40	87.19	76.17
Average for all stover rations	65.19	13.69	72.04	43.75	67.46	83.21	72.04
Average for periods I. and II	64.55	5.87	69.97	41.41	67.48	81.22	69.97

Bringing together those results which may rightly be compared, we obtain from the last table the following:

TABLE XXI.—GENERAL AVERAGES OF DIGESTION OF RATIONS.

RATION AND PERIODS.	DRY MATTER.	ASH.	PROTEIN.	CRUDE FIBRE.	N. FREE EXTRACT.	FAT.	TOTAL NITROGEN.
Silage plus grain ration:							
Average for periods I. and II......	69.94	13.49	70.77	51.30	75.06	83.75	70.77
Corn stover (fodder) grain ration:							
Average for periods I. and II......	64.55	5.87	69.97	41.41	67.48	81.22	69.97

From this table we see that there is but little difference between the digestibility of the silage and the fodder rations, the slight difference found being in favor of the silage. But we must not overlook the fact that this slight difference may be due to the difference in methods of growing the fodder and not to any extent to be attributed to the ensiling. Corn stover has been found to differ but slightly in digestibility from that of fodder corn or corn silage.* The digestibility of the crude protein is very nearly the same in the two rations, the silage being slightly the higher. The fat is also higher in the silage, but this may be due to the amount of acid which the silage contains; in the ordinary processes of fodder analysis, this acid comes out in the ether extract and is reckoned as fat. The percentages of ash digestible will be noticed as quite variable and in most cases very low. But the digestibility of the ash cannot be regarded as of much importance from the fact that no account is taken of the amounts of salt eaten and solids in water drunk. Our ash results seemed so low that this chemical work was repeated, and the results confirmed.

The greatest variations are in crude fibre and nitrogen-free extract; these variations account for nearly all the difference in the digestibility of the dry matter of the dry and succulent materials.

There have been a few experiments made elsewhere that are fairly comparable with those here recorded, as they were made with about the same grain rations. These have been compiled as follows:

*See Results of Penn. Expt. Station, Agr'l. Science, Vol. IV., p. 139.

TABLE XXII.

COMPARISON OF RESULTS IN SUNDRY DIGESTION EXPERIMENTS.

EXPERIMENT.	KIND OF GRAIN RATION.	DRY MATTER.	ASH.	PROTEIN.	CRUDE FIBRE.	N. FREE EXTRACT.	FAT.
Silage Ration:—							
1,—Maryland............	Corn-meal and C. s. meal..	73	20	69	47	82	82
2,—Maryland............	Gluten-meal and germ feed.	67	7	72	55	68	86
3,—Maryland............	Corn-meal...............	76	17	56	60	84	74
Woll,*—1888....	Corn-meal and wheat bran.	63	....	84	61	68	74
Woll,†—1889	" " " " .	63	27	65	49	....	69
Sturtevant‡.............	" " " " .	....	....	62	65	75	87
Average excluding our No.3	....	67	18	70	55	73	80
Corn fodder ration:—							
1,—Md. (corn stover).....	Corn-meal and C. s. meal..	70	7	69	36	76	81
2,— " " "	Gluten-meal and germ feed.	59	4	71	47	59	81
3,— " " "	Gluten-meal and wheat bran	66	29	76	58	67	87
Woll,*—1888............	Corn-meal and wheat bran.	59	...	81	49	65	67
Woll,†—1889............	" " " " .	62	31	66	49	....	57
Sturtevant‡........	" " " " .	...	..	61	64	71	75
Average excluding our No.3	....	63	14	70	49	68	72

*Report of Wisconsin Agr'l Expt. Station,—1888, p. 57. †Ditto,—1889, p. 105.
‡Report of New York Agr'l Expt. Station, (Geneva, N. Y.),—1884, p. 45.

From this last table it will be seen that, in general, our experiment agrees with those mentioned as conducted elsewhere, viz: that silage has but little effect on the digestibility of the albuminoids, but increases the digestibility of all the other compounds.

If we take the total of our experiments and consider simply the digestibility of the albuminoids or protein in a silage ration, as com-

pared with that in a fodder ration, without considering the source from which that protein was derived, we have from table on page 328, sixty-eight (68) per cent. of the protein digested in the silage ration, and seventy-two (72) per cent. in the fodder ration.

If we compare the digestibility of the different grain rations, we find that the most valuable ingredients, protein and fat, are more digestible in the ration composed of gluten meal and germ feed, than in that composed of corn meal and cotton-seed meal; this is also true of the crude fibre. The nitrogen-free extract and consequently, the total dry substance, has the higher percentage of digestibility in the corn-meal and cotton-seed meal ration.

The most digestible ration of those tried here was one composed of corn fodder, gluten meal and wheat bran.

V.—The Relation of the Acids of Silage to Albuminoid Consumption or Decomposition.

The nitrogen-free extract of feeding stuffs is made up of numerous substances, such as the starches, sugars, gums, mucilages, pectins, lignins and the various organic acids. The most of these are believed to have practically the same physiological value as far as they are digestible. Organic acids occur in small quantities in most feeding stuffs, but in the natural state they are generally in combination with bases. In some feeding materials, such as silage and brewers' grains, which have undergone a fermentation and had some of the starch, sugar, etc., broken up into acids, the acid often exists in considerable quantities in the free state.

The question comes to us for consideration in connection with the ensiling of green forage and the feeding of silage, as to whether we gain or lose by the process of fermentation and changing some of the starch, sugars, etc., to acids in the free state. We have seen from the preceding part of our experiment that they have but little effect on the amount of material digested; we now inquire what becomes of that material after it has been digested and whether it is stored in the body.

It has been well established that nitrogen is not excreted to any considerable extent except in the visible ejects,—the dung and urine. It has also been well established that the urinary nitrogen is a measure of the amount of protein or albuminoids decomposed in the body. From this knowledge we can determine whether an animal is gaining or losing nitrogenous constituents (*i. e.*, flesh), and need not rely upon

the inaccuracies of live weight which will fluctuate with the amount of food and water consumed and retained. We need only to compare the nitrogen in the digested portion of the food consumed with that excreted in the urine, although it seems better to compare the total amount of nitrogen in the food with the total of that in the urine and dung. If the amount in the fodder be the greater, it shows that nitrogen has been retained in the body; if on the other hand, the amount in the excrement be the greater, it shows that more albuminoids have been consumed or decomposed than have been supplied and that the animal is losing flesh.

The Acids of Silage. The acids of silage will vary in kind and amount with the character and condition of the materials put in the silo, and with the character and duration of the fermentation which takes place.

The acids can be divided into two general classes:—the volatile and non-volatile. The greater portion of the volatile acids of silage is acetic acid, and lactic acid forms the bulk of the non-volatile portion. The percentage of non-volatile acids is always much higher than that of the volatile. These two classes are supposed to exert a different physiological effect, but just what they are is not known, and it is not within our province to conjecture.

In all the samples of silage used in our experiment, the total amount of free acid was determined by taking from one-half to one pound of the fresh silage and chopping it up with a mince-meat cutter until it was very fine, uniform and thoroughly mixed. One hundred grams of this fine material was placed in a 2000 c. c. flask, then 1000 c. c. to 1200 c. c. water added and allowed to stand for 10 or 12 hours, with occasional shaking. It was then made up to 2000 c. c., passed through a dry filter, and 50 to 100 c. c. taken for each determination. The free acid in this was determined by titrating with tenth normal sodium hydrate, phenolpthaleine being used as an indicator.

The results of the determinations in our samples, together with some made elsewhere are given in Table XXIII.

A comparison of the figures shows our silage to have been about the same in acidity as the majority of others, although a little more acid than some samples.

TABLE XXIII.—PERCENTAGE OF FREE ACID IN ENSILAGE.

INDEX No.	DESCRIPTION OF SAMPLE.	TOTAL FREE ACID.* Per cent.
825	Corn silage fed steers B and D,—Feb. 2nd	1.53
848	" " " " " " " " 9th	1.29
849	" " " " " " " " 10th	1.50
859	" " " " " " " " 11th	2.24
860	" " " " " " " " 12th	2.14
866	" " " " " " " " 13th	1.82
875	" " " " " " " " 14th	1.95
901	Average of above seven samples	1.796
890	Corn silage fed steers A and C,—Feb. 23rd	1.98
895	" " " " " " " " 24th	2.08
896	" " " " " " " " 25th	2.19
902	" " " " " " " " 26th	1.73
909	" " " " " " " " 27th	1.47
916	" " " " " " " " 28th	1.66
943	Average of the preceding six samples	1.851
944	Corn silage fed steer A,—period III.—March 9th	1.54
950	" " " " " " " " 10th	1.73
951	" " " " " " " " 11th	2.27
958	" " " " " " " " 12th	2.24
959	" " " " " " " " 13th	1.89
964	" " " " " " " " 14th	1.86
991	Average of preceding six samples	1.925
47	Corn silage,—Maryland, 1889	2.11
48	Corn and soja beans mixed.—Maryland,—1889	1.44
380	Corn silage,—corn frozen before putting into silo	1.28
	" " "Burr's White,"—Ill. Expt. Station	1.99
	" " "B. & W.,"—corn " " "	2.27
	" " " " " " "	2.45
	" " Pa. State College, from silo, 1883	1.14
	" " " " " compactly packed.—1883.	1.17
	" " " " " looselyand slowly filled,'83	1.26
	" " "Yellow dent,"—Wis. Expt. Station	2.40
	" " " " " " "	0.48
	" " " " " " "	0.14
	" " "White" " " " "	1.42
	" " "Stowell's Evergreen,"—Wis. Station	1.17
	" " "Southern Sweet,"—Wis. Expt. Station	1.73
	" " "B. & W.,"—Wis. Expt. Station	0.99

*Acid calculated as lactic and acetic.

As stated in an earlier part of this paper, the urine was collected during the digestion part of each period, weighed and samples taken and the amount of nitrogen it contained determined each day. The average results of these determinations are given for each steer for the different periods in Table XXIV. From the preceding records, Table XXV. is made up, and its results restated in the Summary.

Table XXIV.—Quantity and Nitrogen Content of Urine.

Steer and Period. Each Period 5 Days.	Weight Urine.	Weight Urine.	Per Cent. Nitrogen.	Weight Nitrogen.
	Lbs.	Grams.		Grams.
Steer A.,—Period I........	33.4	15153.0	1.625	246.23
" " II........	64.6	29299.8	1.408	412.53
" " III........	35.6	16131.2	1.323	213.43
Steer C.,—Period I........	16.7	7569.4	2.000	152.08
" " II........	32.8	14897.9	1.835	273.47
Steer B.,—Period I........	32.8	14784.6	1.702	251.68
" " II........	31.3	14217.5	2.504	356.06
" " III	40.1	18172.4	1.812	329.29
Steer D.,—Period I........	32.6	14727.8	2.069	304.79
" " II........	29.5	13379.4	2.220	296.98
" " III.... ...	31.1	14068.6	2.139	301.02

Summary of Table XXV.

Rations.	Nitrogen fed.	Nitrogen excreted.	Nitrogen stored.	Per cent. of N. fed stored in the body.
Silage rations:—				
Average for all periods.......	701.26	514.98	186.28	26.56
Corn stover ration:—				
Average for all periods.......	728.71	483.31	245.40	33.67

From these results we see that the percentage of the nitrogen fed which was stored in the body, was decidedly greater with the fodder ration than with the silage. This is not only true of the average result, but for each individual steer in each period, with one exception, (that of steer B.,—period II.) These results, with that of the digestibility of the protein of all the rations fed, give a slight advantage to a fodder or stover ration over a silage ration, for fat or flesh production.

Table XXV.

Computation of Nitrogen Stored in Body, during Experiment.

Rations and Periods.	Total Nitrogen fed.	Nitrogen excreted.			Nitrogen Stored in the Body.
		Dung.	Urine.	Total.	
Silage ration:—					
Steer A.,—Period I......	1077.21	341.34	412.53	753.87	323.34
" C.,— " II......	752.14	226.85	273.47	500.32	251.82
Average................	914.67	284 09	343.00	627.09	287.58
Steer B.,—Period I	633.87	188.86	251.68	440.54	193.33
" D.,— " I......	586.60	157.80	304.79	462.59	124.01
Average.	610.23	173.33	278.23	451.56	158.67
Steer A.,—Period III......	456.50	204.14	213.43	417.57	38.93
General average...........	701.26	223.80	291.18	514.98	186.28
Corn-stover ration:—					
Steer A.,—Period I	922.69	279.16	246.23	525.39	397.30
" C.,— " I......	657.46	214.15	152.06	366.21	291.25
Average.	790.07	246.65	199.15	445.80	344.27
Steer B.,—Period II......	674.52	206.68	356.06	562.74	111.78
" D.,— " II......	591.06	157.21	296.98	454.19	136.87
Average.................	632.79	181.94	326.52	508.46	124.33
Steer B.,—Period III......	993.49	230.19	329.29	559.78	433.71
" D.,— " III......	533.03	130.52	301.02	431.54	101.49
Average..................	763.26	180.50	315.16	495.66	267.60
General average...........	728.71	203.04	280.27	483.31	245.40

VI.—Comparison of the Co-efficients of Digestibility before and after the Extraction of the "Stoffwechsel-producte."

The German term "stoffwechsel-producte" is used to indicate all the nitrogenous matter contained in the dung or fæces which has been derived from biliary matter, mucus, the wearing off of the linings of the intestines, etc.

In order to have results for comparison with those of the artificial digestion discussed in a later section, and as a matter of record, the stoffwechsel-productes have been determined by the method devised by Jordan* of the Maine Experiment Station. This consisted in the successive extraction of the fæces with ether, alcohol, hot water and cold lime water. The nitrogen was then determined in the residue. The determinations were made in composite samples of the dung, which were made up for each steer for each period. Table XXVI. gives the results of these determinations, and from it and other data is computed the next table.

Table XXVI.—"Stoffwechsel-producte," as Determined.

Index No.	Steer.	Period.	Water.	Dry Substance.	Total N. in Fresh Dung.	Nitrogen after Extraction.	Difference.
1045	A.	I.	82.47	17.53	0.546	0.454	0.091
1046	C.	I.	81.73	18.27	0.665	0.496	0.169
1047	A.	II.	82.40	17.60	0.625	0.450	0.175
1048	C.	II.	84.71	15.29	0.610	0.463	0.147
1049	A.	III.	84.31	15.69	0.461	0.340	0.121
1050	B.	I.	82.96	17.04	0.492	0.323	0.169
1051	D.	I.	83.46	16.54	0.518	0.261	0.257
1052	B.	II.	82.30	17.70	0.329	0.214	0.115
1053	D.	II.	83.12	16.88	0.366	0.252	0.114
1054	B.	III.	83.87	16.13	0.346	0.232	0.114
1055	D.	III.	84.05	15.95	0.304	0.186	0.118

*Agrl. Science, Vol. II., p. 294.

Table XXVII.—Digestibility of the Nitrogenous Matter.

Steer No.	Period No.	Total Excrement.	Per cent. non-digestible N.	Total non-digestible N.	Total Nitrogen fed.	Total Nitg'n digested.	Per cent. digested.
A.	I.	51129.1	0.454	232.14	922.69	690.55	74.87
C.	I.	32205.4	0.496	159.73	657.46	497.73	75.78
A.	II.	54601.9	0.450	245.71	1077.21	831.50	77.14
C.	II.	37195.0	0 463	172.21	752.14	579.93	77.13
A.	III.	44314.9	0.340	150.63	456.50	305.87	67.10
B.	I.	38385.8	0.323	123.98	633.87	509.89	80.44
D.	I.	30476.1	0.261	79.54	586.60	507.06	86.38
B.	II.	62752.7	0.214	134.28	674.52	540.24	80.00
D.	II.	43006.9	0.252	108.38	591.06	482 68	81.72
B.	III.	66608.3	0.232	154.53	993.49	838.96	84.41
D.	III.	43006.8	0.186	79.99	533.03	453.04	85.02

Bringing together the results for the digestion of the nitrogenous matter, as given under Section IV. of this paper, and to be found on page 328, and those given above, we have the following as the percentage digested.

Steer and Period.	A.—I.	C.—I.	A.—II.	C.—II.	A.—III.	B.—I.	D.—I.	B.—II.	D.—II.	B.—III.	D.—III.
Before extraction.............	70	67	68	70	56	72	73	69	73	77	76
After extraction..............	75	76	77	77	67	80	86	80	82	84	85

We thus see that there is a difference of from five to thirteen per cent. in the amount of nitrogen due to nitrogenous products in the fæces, which did not exist in the food eaten.

VII.—Artificial Digestion.

Within the past few years there has been much attention paid to the matter of devising methods for artificial digestion, and to testing those methods. The importance is evident of having some more accurate method of determining the food value of a feeding stuff, than that given by ordinary chemical analysis, and one more satisfactory than the long, tedious and expensive process of actual digestion experiments with animals.

The method that has proved most satisfactory for artificial digestion has been that which was finally proposed by Stutzer; this is only applicable to the nitrogenous constituents. There have been a number of slight variations from his method in regard to the sources of the materials used and the manner of manipulation, so as to suit the fancies and the means which the user had at hand. In the main, all have digested in pepsin and pancreas solutions for twenty-four hours each, at 40° C.; periodically increasing the strength of the acid of the pepsin solution. Some have reduced the time of digestion in the pancreas solution, and others have omitted it altogether in certain instances.

The pepsin solution, in some cases, has been made up by extraction directly from the inner membrane of a pig's stomach; in others scale pepsin has been used. The pancreas has almost always been prepared from the sweet-breads of oxen, with a variation in method of preparation, according to the user.

Many of the discrepancies which are found to exist, no doubt arise from the variation in the character of substances used in making up the solution, the difficulty of keeping a constant heat for so long a period, the variation in manner of the periodical increase of the strength of acid in pepsin solution and the difficulty of keeping a pepsin solution constant. In former years, I have used the method followed at the Connecticut Experiment Station,* and solutions proposed by Dr. Chittenden, but have found all of the difficulties mentioned above, and on the whole, this has not been very satisfactory.

In the work herewith reported, I have used the scale pepsin and pancreatine made by E. Merck, and have found them very satisfactory, and to be good grades of material, being nearly if not entirely soluble in water. I have followed practically the method of Stutzer as modified by Wilson.† This consisted of treating 2 grams of the

*Report Conn. Expt. Station, 1885.

†Journal of Society of Chemical Industry, Vol. X., p. 118.

substance as ordinarily prepared for chemical analysis with 100 c. c. of a 0.33 per cent. hydrochloric acid solution, add to this 0.1 gram of scale pepsin and place in a loosely corked bottle. The bottles were immersed in a bath of water kept at 40° C. for 12 hours, with occasional shaking. The contents were then filtered, washed until free from acid, returned to the bottle with 100 c. c. of water, 0.15 gram pancreatine and 0.3 gram of sodic carbonate added, and the whole heated again for twelve hours at 40° C., with occasional shaking. The residue was filtered, thoroughly washed, and the nitrogen determined by the Kjeldahl method. This has the combined advantages of reducing the time, having a more constant solution, a fresh solution for each determination, and making the manipulation more simple. The results following are the averages of duplicate and triplicate determinations:—

Index No.	Description of Sample.	Per cent. digested.
808	Corn stover (fodder)	71.55
865	" " "	72.07
930	" " "	75.65
901	" silage	66.49
943	" "	75.25
991	" "	71.91
881	Corn stover refused by steer	80.15
823	" meal	69.11
886	" "	74.69
945	" "	74.69
846	Gluten meal	64.21
921	" "	64.28
966	" "	72.56
847	Germ feed	74.06
824	Cotton-seed meal	84.96
885	" "	85.04
967	Wheat bran	89.82

1057	Corn-meal, c. s. meal and corn stover in proportions fed.......	79.79
1058	" " " " " silage " " ".......	78.65
1059	" and corn silage " " ".......	73.10
1060	Gluten meal, and germ feed and corn silage " ".......	74.23
1061	" " " " stover " ".......	75.09
1062	" " wheat bran " " " ".......	83.33

There is fair harmony in the results obtained with the different samples of the same materials, although occasionally there is too great a variation; this could only be accounted for by error in the method itself.

In artificial digestion the question comes up: Can we determine the co-efficients for each substance separately and then calculate the co-efficients for any ration we choose to make up, or will we have to make up a sample in the proportion we propose to feed, and actually determine the co-efficient in the mixture? To test this point we have determined the percentages digestible in both ways. These results, together with those which we have determined by digestion with the animals, are given in the following table:—

TABLE XXVIII.

CO-EFFICIENTS OF DIGESTIBILITY OBTAINED BY DIFFERENT METHODS.

Steer and Period.	A	B	C	D
			Artificial Digestion.	
	Ordinary digestion with animal.	After extraction of the bile and like products.	Calculated from co-efficients obtained by digesting substances separately.	Substances mixed in proportions fed.
Steer C.--Period 1........	67	76	80	80
" A. " 2........	68	77	81	79
" A. " 3	56	67	73	73
" B. " 1........	72	80	66	74
" D. " 2........	73	82	66	75
" D. " 3........	76	85	77	83
Averages...........	69	78	74	77

From these results we see that there is a difference between the method of calculating and determining the co-efficients in the mixture, but that there is no regular variation. The results determined by the actual digestion of the mixtures, and as given in column D., average much more closely with those given in column B., which is considered to more nearly approximate the truth of digestion with animals, than those of C. Hence, it would seem as though the difference was in favor of the digestion of the mixture as fed, rather than calculating it from the co-efficients determined by the separate digestion of each substance.

There is evident need for more research in this direction, and better methods for artificial digestion.

VIII.—The Manurial Constituents of the Excreta.

Nitrogen being the most valuable constituent of farm-yard manure and the most expensive to purchase in commercial fertilizers, and from the great loss of this plant food that is going on constantly on every farm, especially in the liquid portions of the excreta, it seems desirable to call especial attention to the relative amounts of nitrogen contained in the urine and dung, as shown in the table on page 335.

The average of these results show that over fifty-seven per cent. (57%) of the nitrogen excreted is contained in the urine. This plainly shows the necessity for using plenty of litter in our stables to absorb all the urine, and also that we should prevent leaching and drainage of the manure pile.

IX.—A Comparison of the Percentages of Crude and Purified Fat in the Materials Fed and in the Fæces, and their Effect on the Digestion Co-efficients.

That much of the Ether extract of fodders and the fæces are other than fat, and that they are substances which have a very different feeding value from that of fat is generally conceded; yet there has been little effort toward a modification of our methods so as to exclude them, and toward a determination of their relative values in

feeding. Some time ago I suggested a method for the purification of our Ether Extract by means of animal charcoal.* In the feeding experiments previously described, some of the samples were selected so as to represent the different classes of materials used and the fat determined by this modified method. The results of these determinations, together with those by the ordinary method, are given in the following table :—

Table XXIX.

Fat by New and Old Process in Food and Dung, Compared.

Index No.		Fat by ordinary method.	Fat by modified method.	Difference.
	Steers A. and C., Period II.			
885	Cotton-seed meal............	13.41	12.65	0.76
886	Corn meal..................	2.42	2.42	0.00
943	Corn silage..	1 02	0.75	0.27
1047	Dung,—Steer No. 1..........	0.61	0.49	0.12
1048	" " " 2..........	0.89	0.71	0.18
	Steers B. and D., Period III.			
966	Gluten meal................	16.87	16.87	00.00
967	Wheat bran	6.15	4.95	1.20
930	Corn stover................	3.85	2.51	1.34
1054	Dung,—Steer No. 3..........	0.53	0.48	0.05
1055	" ". " 4..........	0.45	0.37	0.08

*Report,—Md. Agr'l Expt. Station, 1890, p. 126, and American Chemical Journal, Vol. XII., p. 261.

TABLE XXX.

PERCENTAGES DIGESTED OF CRUDE AND PURIFED FAT.

(*Computed from preceding data.*)

	Food Consumed.		Steer A.		Steer C.	
	Steer A.	Steer C.	Fat by old method.	Fat by new method.	Fat by old method.	Fat by new method.
Corn-meal	18144.0	11340.0	439.09	439.09	274.43	274.43
Cotton-seed meal	9072.0	6804.6	1216.56	1147.61	912.42	860.70
Corn silage	54488.7	33027.7	555.78	408.67	336.88	247.71
Total eaten	......	......	2211.43	1995.37	1523.73	1382.84
Total excreted	54601.9	37195.0	335.09	267.55	332.56	264.09
Digested	......	......	1876.34	1727.82	1191.17	1118.75
Per cent. digested	......	......	84.8	86.6	78.2	80.9

	Food Consumed.		Steer B.		Steer D.	
	Steer B.	Steer C.	Fat by old method.	Fat by new method.	Fat by old method.	Fat by new method.
Gluten meal	9072.0	4536.0	1530.44	1530.44	765 22	765.22
Wheat bran	9072.0	4536.0	557.93	449.06	278.96	224.53
Corn stover	17945.5	12162.1	690.90	450.42	468.28	305.26
Total eaten	......	......	2779.27	2429.92	1512.42	1295.01
Total excreted	66608.3	43006.8	353.78	319.72	193.95	159.12
Digested	......	......	2425.49	2110.20	1317.47	1135.89
Per cent. digested	......	......	87.3	87.2	87.1	87.7

That the co-efficients of digestibility by these two methods should agree so closely is rather surprising; yet there is enough difference in some cases to warrant making an allowance for it. The differences in the percentages of fat, as they exist in the different foods, makes it manifest that they should be recognized, and that there is need for investigation as to the food values of the various substances extracted by ether.

In the determination of the amount of alkali required to saponify the fat before and after purification, both in the feed and fæces, the results obtained agreed very closely, which shows that much of the material was of an unsaponifiable nature, and not related to the fats or even true waxes.

Further tests were made to see if any of the crude extract was soluble in water, with the result that in all cases some matter was soluble and in many cases considerable. This water-soluble material, as far as could be examined, showed none of the characteristics of fats, and was believed to be entirely foreign to them.

X.—The Consumption of Albuminoids as Effected by Vegetable Fats.

In the use of the concentrated cattle foods containing high percentages of fat, the question arises as to whether they serve to decrease the amounts of nitrogen-free extractive matter necessary in a ration, and whether there will be proportionately less of the nitrogen-free extract digested. Also, it is desirable to know if the fat will have a tendency in a fattening ration to diminish the consumption of albuminoids, and consequently increase the amount of flesh formed. Hoope-Seyler describes (Physiologische Chemie, Part IV., p. 909,) the power of fat food to increase the amount of work performed, to its influence in diminishing the consumption of nitrogenous tissues. While their statement may be true for working animals, it was a question in my mind if the same fact would hold for animals at rest or gaining flesh.

With the object of getting a little data on this point, we have used some of the results of the previous experiments. The results obtained are not at all conclusive in their character, as the data is too limited in amount, and there should be greater variations in its character and the way it is obtained, before definite conclusions could be drawn; yet we believe that our data gives certain indications.

With steers B. and D., the food of period III. was changed from that of period II., so as to decrease the amount of fat and increase the protein, while the nitrogen-free extract remained about the same. The results obtained are given in the following table:—

Table XXXI.

Relative Amounts of Fat, Nitrogen-free Extract and Protein, Fed and Digested.

	Fat.	N. free extract.	Protein.	Ratio of Fat to N. free extract.	Ratio of Fat to Protein.
Steer B.—period II.					
Eaten	2585	12413	4213	1 : 4.8	1 : 1.6
Excreted	487	5153	1292	1 : 11.2	1 : 2.6
Digested	2098	6960	2921	1 : 3.3	1 : 1.4
Per cent. digested	81	56	69		
Steer B.—period III.					
Eaten	2779	16427	6212	1 : 5.9	1 : 2.
Excreted	354	5212	1441	1 : 14.7	1 : 4.0
Digested	2425	11215	4771	1 : 4.6	1 : 1.2
Per cent. digested	87	68	77		
Steer D.—period II.					
Eaten	2236	9306	3692	1 : 4.2	1 : 1.6
Excreted	409	3517	983	1 : 8.6	1 : 2.4
Digested	1827	5789	2709	1 : 3.2	1 : 1.4
Per cent. digested	82	62	73		
Steer D.—period III.					
Eaten	1512	9701	3332	1 : 6.4	1 : 2.2
Excreted	194	3343	816	1 : 17.2	1 : 4.2
Digested	1318	6358	2516	1 : 4.8	1 : 1.9
Per cent. digested	87	66	76		
Average for steers B. & D.—period II.					
Eaten	2410	10859	3952		
Digested	1963	6374	2815		
Average for steers B & D.—period III.					
Eaten	2145	13064	4772		
Digested	1871	8786	2643		

From these figures we can see that the increasing of the relative amounts of fat fed to that of protein fed did not increase the relative amount of protein digested or of the Nitrogen-free extract saved; and that there were higher percentages digested where the food contained the lower per cent. of fat. From Tables XXXI. and XXXII. it appears that the fat has not had a very apparent influence in diminishing the consumption of the nitrogenous matter or increasing the amount of nitrogen stored in the body.

TABLE XXXII. NITROGEN RECORD.	TOTAL NITROGEN FED.	NITROGEN STORED IN THE BODY.	PER CENT. FED STORED.
Steer B.,—period II	675	112	16.59
Steer D.,—period II	591	136	23.01
Average	633	124	19.59
Steer B.,—period III	993	434	43.71
Steer D.,—period III	533	102	19.10
Average	763	268	35.13

SUMMARY OF RESULTS OF THE FEEDING EXPERIMENTS.

Practical Points.

1. The digestibility of the albuminoids, with a fodder and silage ration, was practically the same.

2. The dry substance and the non-nitrogenous matter were slightly more digestible in the silage ration than in the fodder.

3. The acids of silage increased the consumption or waste of the albuminoids stored in the body, thus preventing flesh formation.

4. In the silage ration, 27 per cent. of the nitrogen fed was stored in the body; while in the fodder ration 34 per cent. of the nitrogen fed was stored in the body.

5. Fifty-seven (57) per cent. of the nitrogen in the total excreta or manure was found in the urine.

6. An excess of fat or vegetable oil in a ration did not increase its digestibility, and did not diminish albuminoid consumption or increase flesh formation.

H. J. P.

REPORT OF THE AGRICULTURIST.

By Albert I. Hayward, B. S.

I.—Silos and Silage (or Ensilage).

In all the previous reports of this division of the Station, record has been made of the experience in growing, storing and feeding silage, or ensilage, on this farm. Silage is now generally recognized as a staple food for most classes of farm stock, and a desirable factor in farm economy whenever conditions are favorable. The questions of greatest economy in constructing silos, in producing silage and in storing it are still open to discussion and worthy of such further experiments as will add to the stock of definite information on these branches of the subject.

Silos.—It is practically agreed that silos or storing pits may be built of a variety of materials, stone, brick, concrete, cement and wood, and be about equally satisfactory in results, if properly managed. In a firm clay soil, or hard-pan, a simple hole in the ground may be made to serve the purpose very well. For this State we are inclined to advise a comparatively inexpensive structure of wood, built mainly, if not wholly above ground, although in some cases there may be ultimate economy in a more elaborate and enduring silo. In our Second Annual Report, page 95, we fully described the silos cheaply built on the College farm during the summer of 1888. It was inadvertently stated, however, that the lining boards of all three of the compartments or pits were coated with creosote oil before being put in place. This was at first intended and believed to be desirable, but for the purpose of comparison, only one of the pits was finally thus treated; in the second, the interior surface was coated after the matched boards had been put on and driven closely together, and in the third pit, this preservative dressing was omitted. These lining boards were of Virginia pine, narrow and matched, like flooring. After the last mentioned pit had been emptied, in the summer of 1891, it was found that the lining boards were decayed in spots. There were places in various parts of the silo which had become so soft that a fork could be easily thrust through to the tarred paper beneath. This condition was not extensive and had not apparently affected the contents of the silo up to that time, and it is

possible that it might have done good service a fourth season; but it was deemed best not to risk losing the silage, and this pit was relined before being filled last autumn. This time cypress boards were used, six inches wide and matched; these being sixteen feet long, extended without joints from top to bottom of the pit; they were closely driven in nailing, and received no oil coating or other preservative. The two silos which were dressed with creosote oil, as above described, remain perfectly sound. It is our practice to examine the interior of every silo, as soon as emptied and where spots of mould appear on the lining, under which decay would be likely to begin, to scrape these well and leave the whole inside clean and with an opportunity to dry. The comparison of these three pits relates only to their own preservation or lasting qualities; it is evident already that the oil coating which was easily and cheaply done, was good economy. There appears to have been no difference in these silos as to keeping their contents; but they cannot well be compared in this respect, as they are opened at different times and therefore are not under like conditions for such comparison. It is intended to build other silos on the College farm or at the Station and test some of the cheapest and simplest forms of construction in wood.

The Silage of 1890.—The details of storing silage in 1890 were given in the Third Annual Report, but the results of this filling have not yet been reported. It was stated that silo No. 3 was opened December 13, 1890. The silage was in fair condition, an average of less than four inches of decayed material was found on top, it was then expected to weigh the entire material removed from this silo and ascertain the per cent. of loss. Just here comes in the question of the most economical mode of opening and feeding from a silo.

If a silo is partially uncovered and fed from the side, removing from one to three inches of the surface silage per day, there is no appreciable loss in that portion fed from; but this leaves an upright surface exposed to the action of the air, and often this exposed surface has more decayed material upon it than was found on the top. In colder climates this decay is much less marked than in Maryland, as the cold lessens the activity of the germs of decay. Again, if the whole surface is uncovered at once, and the number of animals fed from it is small, the decay sets in from the top and proceeds more rapidly than the silage is fed out, thereby increasing the loss. The most economical mode of using silage is to have the silos,

or parts of silos, of such a size as to accommodate the number of animals to be fed, using enough of the silage from the top each day to keep in advance of the progress of decay.

In the case of silo No. 3, the percentage of decomposed material on top was very small, probably at the time of opening it was less than 8 per cent. of the whole, but the loss before being emptied aggregated no less than 43 per cent. of the entire material taken from the silo. This silage consisted of a mixture of corn and soja beans. It was noticed that upon exposure to air the soja beans quickly changed, acquiring a certain musty smell which seemed particularly objectionable to cattle. Silage of this character was refused by the cattle and was included in the loss of the silo. The improvement in quality of the silage by the introduction of the soja bean was in this case more than balanced by the marked increase in decayed material, probably resulting therefrom.

It was intended to compare the amount of edible silage in silo No. 3 with that of No. 1, which was filled with corn, packed whole and heavily weighted, but this was abandoned on account of the very dissimilar character of the materials, and the circumstances being so adverse to any practical result.

Silo No. 1, filled with a young succulent growth of fodder, put in whole, was opened the first of January, 1891. This silage had decayed very much more around the sides than in the pits filled with cut fodder. The great difficulty in removing the material and the loss, by stock not eating the large stalks, makes this a very expensive way of storing silage. In a large silo there would be less loss comparatively than in a small one.

Silo No. 2, the lower part of which was filled with a mixture of corn and soja beans, and the top with corn alone, was opened July 28th, and was used to supplement summer and fall pasture. This silage had kept in very good condition; there was about the same loss on top as reported for No. 3, but less loss in feeding.

The Silage of 1891:—During the season of 1891 the college has purchased a good portable farm engine, and also replaced the "Lion Ensilage Cutter" with an "Ohio Ensilage Cutter, No. 16," with a capacity of five to seven tons per hour. This is a rotary cutter, with four knives, cutting from one-fourth inch to two inches in length, and having a carrier which will work either at right angles or straight ahead. In operating there was found to be very much less strain on

the machine when the carrier was running straight. With these additions to our machinery, we have succeeded in reducing the cost of storing somewhat, and are independent of other parties, who are often disappointing, because the busy season brings calls for an engine from various places at the same time. All of the silos were this year filled with corn cut into half-inch lengths, no other material being mixed with it, with the single exception of a layer of sedge grass or broom-sedge, (Andropogon scoparius,) covering half of silo No. 1, about a foot thick, in the middle of the silo; this was done to learn the effect of ensiling this plant otherwise so unpalatable when full grown. The corn was at or slightly past the "roasting-ear" stage, and was considered nearly perfect for silage as to growth, maturity and proportion of grain to stalk.

Silos No. 1 and No. 3 were empty, and after a slight covering of the earth bottom with cut hay, were filled and allowed a couple of days to settle, then refilled, covered with plank, and No. 1 weighted, while No. 3 received no weight. Silo No. 2 having a few tons of good silage in it still unfed, from the crop of 1890, was carefully cleaned of decayed material, and the remaining good silage was then covered with new corn. The new silage was allowed to settle, and after refilling, was covered with plank, and a small amount of weight especially applied at the corners. One boy was all that was used at any time in packing or treading the silage into the pits.

In the three silos we have stored 4,320 cubic feet of material, measured after settling. Allowing 35 pounds per cubic foot as the weight of the stored material, (which is five pounds below what is generally given as the average weight of corn silage,) and we have a little over 75 tons. The total cost of storing this quantity of silage was $56.46,—divided as follows:—Fuel for engine, $2.50; cutting in field, $10.75; hauling to machine, $13.20; men required at the machine and in the silo, $28.00; weighting silo No. 1, $2.00. This makes between 75 and 76 cents per ton. The wear and tear of machinery is not included, but as both machines are apparently as good as new, it is hard to estimate the exact amount to be allowed for this.

II.—Fodder Corn Grown for Silage in 1891.

The corn used for filling the silo was grown on land adjoining the stable, very conveniently located for economy in handling. The land received a good dressing of stable manure, which was plowed under,

and the soil was reduced to a very fine mechanical condition with harrow and roller. The seed was sown in drills 3 feet 9 inches apart with the Eclipse drill, and when the corn was about six inches high it was thinned to one foot apart. Weights of samples taken from various parts of the field show that the average yield was nearly 19 tons per acre. Nearly every stalk produced one ear, and many of them two; this adds greatly to the value of the silage.

Some special trials were made with the same corn at another place, having in view comparisons in methods of planting corn for silage, in methods of cultivation and as to time of cutting for the silo. Twelve (12) plots were planted, using different distances between the rows, different distances in the row, and in some adding other plants. The plots were located on land immediately south of the Station building. This land is thoroughly under-drained with tile laid thirty feet apart. It was in very fine mechanical condition when planted, and received at that time a dressing of 520 lbs. of

TABLE I.—ARRANGEMENT OF FODDER CORN PLOTS.

Methods of Planting and Cultivation.

Plot Number.	Seed Used.	Between Rows.	Space in Rows.	How Cultivated.
No. 1	Corn	2½ feet.	9 ins.	"Iron Age" cultivator
" 2	Corn	3 "	9 "	do.
" 3	Corn	3½ "	9 "	do.
" 4	Corn	3½ "	12 "	do.
" 5	Corn	3½ "	6 "	do.
" 6	Corn	3½ "	9 "	Deep culture.
" 7	Corn	3½ "	9 "	Shallow culture.
" 8	Corn and sorghum—half and half	3½ "	....	"Iron Age" cultivator
" 9	Corn and sorghum—one to two	3½ "	....	do.
" 10	Corn and sorghum—one to many	3½ "	....	do.
" 11	Corn and cow pea—half and half	3½ "	....	do.
" 12	Corn & Jerusalem corn—one to many	3½ "	....	do.
" 13	Jerusalem corn	3½ "	....	do.
" 14	Chinese sorghum	3½ "	....	do.

dried fish per acre, sown in the row with the seed. In the spring of 1890, this lot received a scanty application of lime and was that year planted with potatoes, being fertilized with dried fish and muriate of potash at the rate of 1,000 lbs. per acre.

The land and season were favorable for a large yield, and the uniformity of the crop on this field was a subject of comment with all who saw it. Especial attention was given to considering the best time to store the corn for silage, based upon its comparative maturity. For this purpose the corn was sampled, weighed and analyzed at three stages of its growth—first, when the kernel was yet unformed, but the cob was pretty well developed; second, when the kernel was milky and in some cases getting a little hard; third, when the kernel was hard and nearly ripe enough to harvest for grain. In Table II., we have given for each of the three stages the weight of product per acre and the percentage of water contained in the sample, together with the calculated yield of dried fodder per acre. The greater the proportion of dry substance the more valuable the forage. Not only is it more economically handled, but it requires less to make up the ration, and for a given amount of animal food less room is required in the silo. At the same time the succulent and palatable blades and tops must not be sacrificed for corn and cobs. Taking the average of the first seven plots, planted with corn alone, and comparing the dry substance and the total green forage in the three stages, we find the ratio of dry to green substance in the first two stages is practically the same, being 1 to 4.80 and 1 to 4.83, respectively, but between the first and second stages there was an increase of 23 per cent. in the product, per acre. The ratio of dry to green substance at the third stage is 1 to 3.6. This is a decided gain over the other stages in the proportion of dry substance, but the total green forage per acre in this case shows an actual decrease of 4.2 per cent., as compared with the second stage. This loss in weight is beneficial, however, as we find a gain of 28.7 per cent. of dry substance over the second stage, and this much more than offsets the loss in green weight. Putting this in another way, we may say that in handling 17 tons, the yield of green forage at the first stage, we should lift 13½ tons of water or more than four-fifths of the whole weight, and only about 3½ tons of dry matter. In the second stage the proportion remains very nearly the same, but we have an actual increase of nearly one-fourth in the crop; this is all gain, except the cost of handling the increased amount. As between the second and third stages we have a less

amount to handle by nearly a ton and a change or a gain in the dry substance of nearly one-third, amounting to $1\frac{1}{4}$ tons; this is worth as much more for stock food over the second stage, as cured corn-fodder is worth more than water.

On plots 1, 2 and 3 the stalks of corn were thinned to nine inches

TABLE II.—PRODUCT OF FODDER CORN, GREEN AND DRY, PER ACRE.
With Moisture and Ash at different Stages of Growth.

1ST STAGE. Kernel unformed. Silk well out. Sorghum in bloom.				2ND STAGE. Kernel in dough state. Some a little solid. Sorghum ditto.				3D STAGE. Kernel quite hard. Though hardly ripe enough to stock. Sorghum seed hard.			
PER CENT.		PER ACRE. TOTAL YIELD LBS.		PER CENT.		TOTAL YIELD PER ACRE.		PER CENT.		TOTAL YIELD PER ACRE.	
Water.	Ash.	Green Fodder.	Dry Substance.	Water.	Ash.	Green Fodder.	Dry Substance.	Water.	Ash.	Green Fodder.	Dry Substance.
81.45	1.10	44160	8191	81.16	1.21	53760	10128	73.09	1.39	51200	13772
82.23	1.04	46720	8302	80.04	1.12	48000	9581	71.95	1.08	41600	11668
80.48	1.34	35840	6996	78.73	1.09	39040	7930	73.48	1.24	39680	10523
81.61	1.10	30720	5649	79.20	1.06	36480	7588	71.36	1.30	39040	11181
79.85	1.29	30080	6061	74.03	1.06	38400	8053	74.58	1.09	45800	11642
77.92	1.24	30080	6859	78.11	1.20	35840	7845	68.51	1.40	24320	7658
80.07	1.28	30720	6123	77.23	1.26	42240	9618	70.87	1.20	40320	11745
78.50	1.63	28160	6054	80.43	0.97	38400	7515	75.13	1.15	29440	7322
81.15	1.10	23040	4343	80.31	1.04	38400	7561	70.41	1.08	35840	10604
78.94	1.18	24960	5257	77.33	1.05	30720	6964	72.80	1.20	30080	8182
77.10	1.26	25600	5862	78.82	0.95	26880	5693	71.59	1.13	28800	8182
78.27	1.33	26880	5801	77.41	1.05	32000	7229	72.88	1.13	32000	8710
75.47	1.56	11520	2826	74.74	1.63	12800	3234	61.13	2.04	14720	5722
81.37	1.05	22400	4173	72.84	1.00	30720	8344	73.35	1.30	33280	8869

apart in the row. The distance between the rows was 2½, 3 and 3½ feet, respectively. These variations have a marked effect upon the character of the product. We first notice that the rows planted nearest together have the greatest content of water. This variation, however, is very slight, being 78.56, 78.07 and 77.56 per cent., respectively, or only one per cent. between the extremes. If we take the average of the three cuttings for comparison as representing the yield of dry substance per plot, we have the plots standing as named, in the following relation:—1.26, 1.16, and 1,—or, expressed in tons of dry fodder, 5.3, 4.9 and 4.2; this is decidedly in favor of the rows 2½ feet apart. As already stated this was an unusually favorable season for corn, and these results might and probably would be somewhat different, in a less favorable year. A comparison was also instituted between Plots 3, 4 and 5, having the rows the same distance apart, but the corn thinned to different distances, namely, nine, twelve and six inches, respectively. As in the previous case the multiplicity of stalks increased the yield, but with the increased numbers of stalks came the increase in water content; the range between extremes is small, however, being only one-half of one per cent. The character of the culture was also compared. Where the "Iron Age" cultivator was used, the corn was subjected to ordinary culture, as this implement is a common one-horse cultivator, having three inch steel plates for teeth. Deep culture was done with a plow, and in the manner commonly known as barring,—the soil being first thrown from the row, leveled a few days later and finally thrown towards the row. The shallow culture was accomplished with an implement using teeth which ran nearly flat, just under the surface of the ground, merely stirring the soil for an inch or an inch and a-half in depth. A dynamometer was used to test the draft of these different implements; the average was found to be as follows:—one-horse plow, 465 lbs.; Iron Age cultivator, 435 lbs.; Flat Tooth cultivator, 269 lbs. There is little difference between the plow and the Iron Age cultivator, the former being six per cent. or 30 lbs. harder to draw. With the flat tooth cultivator the stated draft is only about 57 per cent. of that of the plow. The amount of earth moved by each implement is not known, but probably bears a close relation to the draft of the same. The plow turned a furrow five inches deep, the Iron Age cultivator ran from three to four inches deep, while the Flat Tooth cultivator was not deeper than two inches at any place. The apparent effect of these different methods of cul-

tivation should now be examined. The plots taken for this comparison are Nos. 3, 6 and 7. In these the rows are the same distance apart, and the stalks in the row are equal. The yield in dry substance stated in their order is 8483 lbs., 7454 lbs. and 9126 lbs., respectively. Stated in the order of the depth of cultivation, deep, medium and shallow, we have 7454, 8483 and 9126, or a progressive increase with the shallowness of culture. We have here a difference of nearly 19 per cent. in favor of shallow culture, and this method cost in force, or power expended, less than three-fifths that of the deep culture. Estimating the cost by the force used in cultivation, the shallow method produced the same amount of dry substance with only 47 per cent. of the labor required by the other methods.

The crop which showed the greatest amount of dry substance, as compared with the green forage, was the Jerusalem Corn, on plot 13; this is a variety of non-sacharine sorghum, and of no particular value in this latitude, because of the small growth obtainable. The addition of sorghum in the corn rows has, in many cases, somewhat lowered the per cent. of water in the material, but there has been no increase in gross yield from its use.

III.—Soil Test with Corn.

In the soil tests that have been made and reported by this Station, two series of plots have been used. The first series, of rather light sandy loam, has been in use three years, the same fertilizer being applied year after year. This series of soil tests has been fully reported upon in our Bulletin No. 14, on Wheat. The third and last crop harvested being wheat, was properly reported in this bulletin, and some conclusions were drawn from the data for these three years. The second and more permanent series of plots for this work was cropped with wheat in 1890, and the history, location, mode of marking and character of the soil, together with the results from the crop of wheat, were published in Bulletin No. 10 of this Station, in September, 1890. For convenience the description of soil is here repeated:—"The soil is a clayey loam of medium color and fairly uniform in quality. The land is not underdrained, but has a gravelly subsoil and good natural drainage. There is a general but gentle slope towards the north, and a part of the field falls slightly towards the east. The land had been pretty steadily cropped for a number of years prior to 1888, with little or no manuring, and was well worn as regarded fer-

tility." The plots are 23 in number, each 208 feet 8½ inches long by 20 feet 10½ inches wide, thus being each just one-tenth of an acre. There are spaces 6 feet wide between the plots, in order to completely separate them, and prevent the influence of fertilizers being felt on contiguous plots. The boundaries of the plots are very carefully marked. This land, which was wheat stubble without grass, was plowed April 24th and 26th, working across the plots to secure uniformity in treatment; it was then carefully worked with cut-away harrow and with a smoothing harrow. The fertilizer was applied May 9th, by hand, broadcast, special pains being taken to secure even distribution. The field was check-rowed 3 feet 6 inches each way; this gave six rows in width on each plot, with the outside rows one-half distance from the plot lines. The space between plots was occupied by a single row of corn. This row was without fertilizer, and was put in to fill the space, in order to have the land uniformly covered with the crops. Planting was done May 12th, covering the seed with a smoothing harrow. This left the land in very good condition, smooth, fine and light. The cultivation was thorough and identical over the field, the horse cultivator being used on June 6th and 18th, July 6th and 27th, and August 6th. At harvest the rows occupying the spaces were first cut and removed; then each plot was cut and put into one large stook at the end of the plot; this was October 6th. It was husked out the 2nd of December; the corn sorted, and the sound corn, the soft corn and the fodder separately weighed.

Notes on Soil Test with Corn:—The results obtained on this series of plots differ very materially from those reported for the other series, noted above. The yields of the plots seem to bear little relation to the fertilizer application. More effect will probably be observed in the years to come.

The Lime plots Nos. 1, 2 and 3, average 50 bushels of shelled corn per acre, which is more than the average yield of the three "complete fertilizer" plots, Nos. 11, 21 and 22. This indicates that there is much inert plant food in the soil, which is developed by the application of lime. This is further shown by the results from the applications of the three important plant-food elements, when used separately. Plots 6, 7 and 8 not only give no marked increase in yield over the "nothing" plots, Nos. 9 and 18, but

fall below Lime, Marl, and Land Plaster. And in combinations, as on plots 10, 11, 12 and 13, the results are scarcely better.

TABLE III.—SOIL TEST WITH CORN.

Plot Number.	Fertilizer per Acre.		Missing Hills.	Yield per Acre.			
	Kind.	Am't.		Hard Corn.	Soft Corn.	Total Corn.	Fodder.
		Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
Plot 1....	Stone Lime...	2000	26	3230	340	3570	7050
" 2....	Oyster Shells Burned......	2000	13	3000	320	3320	6500
" 3....	Oyster Shells Ground......	2000	9	3340	200	3540	7180
" 4....	Marl.....................	4000	24	2900	300	3200	4500
" 5....	Land Plaster.............	233	31	2800	380	3180	4700
" 6....	Bone Black...............	350	24	2200	280	2480	4920
" 7....	Muriate of Potash.	150	34	2220	260	2480	4260
" 8....	Nitrate of Soda...........	150	36	1220	390	1610	3400
" 9 ...	Nothing..................	....	40	1780	250	2030	4050
" 10....	{ Nit. Soda...............	150	..	....	...	....	....
	{ Mur. Potash............	150	18	2240	360	2600	4700
" 11 ...	{ Nit. Soda..............	150	..	....	...	....	....
	{ Mur. Potash............	150	..	....	...	....	....
	{ Bone Black	350	39	2100	290	2390	5420
" 12...	{ Nit. Soda...............	150	..	....	...	....	....
	{ Bone Black.............	350	40	2400	330	2730	5600
" 13...	{ Mur. Potash............	150	..	...	...	....	....
	{ Bone Black.............	350	27	2440	210	2650	5680
" 14 ...	Thomas Slag..............	340	18	2900	310	3210	5840
" 15....	S. C. Dis'd Rock..........	364	18	2160	340	2500	5100
" 16....	Orchilla Guano..	364	16	2840	300	3140	6400
" 17....	Sulphate Iron.............	50	29	1540	380	1920	4400
" 18....	Nothing..................	....	28	2210	200	2410	5000
" 19....	Kainit....................	512	35	3400	150	3550	7300
" 20....	Castor Pomace............	364	41	2800	230	3030	6000
" 21....	{ Nit. Soda..............	150	..	....	...	....	....
	{ Mur. Potash............	150	..	....	...	....	....
	{ S. C. Dis'd Rock.........	364	16	3940	160	4100	8600
" 22....	{ Dried Blood............	179	..	....	...	....	....
	{ Mur. Potash...	150	..	....	...	....	....
	{ S. G. Dis'd Rock........	364	13	3560	180	3740	8200
" 23....	Stable Manure............	4010	21	2600	200	2800	6100

Plots 21 and 22, having complete fertilizers, show a very much increased yield, which may be partly accounted for by the fact that these two plots occupy the crest of the slope; although plot 11 received the same fertilizers, it gave only half as great a yield. Of the different fertilizing materials used between plots 14 and 20, the application of kainit gave the best yield, (50 bushels per acre,) while with sulphate of iron the yield was only about three-fourths as much as on the "nothing" plot, on one side of it.

The detailed record of the season's work is given in Table III. For the future study of these plots, upon which it is intended to apply the same fertilizers, year after year, to secure the cumulative effects, it is necessary to complete and preserve the yearly record, from the first. Thus far, however, this field serves mainly as an illustration of the time and labor necessary to bring into condition for satisfactory experiments with fertilizers, a piece of land, the previous history of which is comparatively unknown. It also illustrates the great difficulty of laying out plots for field experiments, which are wholly free from inequalities of soil or other local influences.

IV.—Other Corn Trials, Increase of Grain.

If one walks through a field of corn, at the time when the pollen sacks are opening, a slight jar of the plants will bring forth a cloud of bright yellow pollen from the tassels; a very large part of this pollen is wasted, because it is not needed to fertilize the silk or kernel germs. It takes much strength from the plant to produce the tassel and pollen, and if the plant food or vital force thus wasted could be directed into the ear and kernel, it might produce a better development of those parts. There is really need of only enough tassels in a field to properly fertilize all the stalks or plants, and the rest might be dispensed with.

Acting upon this idea, as has been done elsewhere, an attempt was made to force into the ear an extra growth and development, by removing some of the tassels, as soon as they appeared. Every third row in a section of the regular corn-field of the College farm, was left to fully develop its tassel and furnish pollen for its own row and the one on either side of it. From these other two rows in every three, the tassels were removed. The labor of doing this was light, as the tassels can be easily pulled off from two rows at a time, by a man walking between them, and almost as fast as he can walk, if the

corn is not too tall. The results of this trial can be best shown in tabular form, as follows:—

TABLE IV.—RESULTS OF REMOVING TASSELS FROM CORN.

Rows Undisturbed.				Rows with Tassels Removed.			
No. of Rows.	Yield of Corn—Lbs.			No. of Rows.	Yield of Corn—Lbs.		
	Sound.	Soft.	Total.		Sound.	Soft.	Total.
1	195	28	223	2 and 3	472	42	514
4	280	26	306	5 " 6	490	34	524
7	228	48	276	8 " 9	455	44	499
10	180	37	217	11 " 12	428	48	476
13	280	28	308	14 " 15	450	29	479
16	257	21	278	17 " 18	480	49	529
19	221	23	244	20 " 21	380	42	422
22	180	33	213	23 " 24	274	45	319
25	120	38	158	26 " 27	234	25	259
Average per Row—Lbs.			247	Average per Row—Lbs.			223

Notes:—The greatest yield was at the rate of fifty-seven (57) bushels of corn per acre, and was from an undisturbed row. To make close comparisons the figures in the right hand column must be divided by two, as the rows were harvested together. These being done, it is found that in the nine comparisons of rows side by side, only two of the rows with tassels removed exceeded in yield the undisturbed rows next to them. In seven cases the result was decidedly the other way. In this trial, the result of removing tassels was unfavorable to the production of grain. Nature's way seems to be the best way.

V.—VARIETY TEST OF OATS.

The usual test was made in 1891 for a comparison of varieties of oats, this time embracing forty-four (44) lots of seed, under forty-two (42) different names. This trial was made in the field southeast of

the Station building, and upon the series of plots next to the turnpike. This land produced a crop of soja beans in 1888, and has since been uniformly treated and used for the variety tests of cereals. The soil has improved in quality and condition, but is not yet sufficiently drained to enable spring grain to be sown early enough. The oat crop is evidently an uncertain one upon this farm, at the best, and this fact, coupled with the wet spring, which forced late sowing, mainly accounts for our failure to product a crop worth recording in detail, for the season of 1891, upon the plots mentioned.

Poor crops are as unsatisfactory to deal with in experiment work as in regular farming, but they are not wholly lost, as more or less information can be obtained if a fair proportion of the plants reach maturity at about the usual time. Poor as our oat crop was, as a crop, the past year, it was still possible to compare the varieties in several respects, for they were all subjected to like conditions throughout their growth. The plots measured one-fortieth of an acre of each lot of oats, as sown, and one-fiftieth as trimmed and harvested. Every plot bore enough to show the characteristics of the variety.

Notes on Crop of 1891:—The American Banner was the most prolific, followed close by Surprise, Barley, Early Arkangel, Unknown, Badger Queen, Canada White, Probstier and Virginia Winter. None of the varieties reached the standard weight per bushel for oats separated and cleaned. Our notes show no relation of weight of grain to source of seed, or latitude where grown. Five of the varieties grown in 1891, weighed 30 lbs., or over, per standard bushel; of these two were the product of seed grown at this Station in 1890, and which were unusually inferior in appearance. (This seed was used because the same varieties could not be obtained elsewhere.) Again,—we grew two lots of American Banner, the seed obtained respectively from Maine and New Jersey; the former produced the best crop obtained, (which was only 24 bushels per acre,) while the latter produced just half as much; plots side by side. The weight, per measured bushel, of these two (crop of 1891) was practically the same. Two lots of Clydesdale were also grown on adjoining plots; one was from seed grown in Maine and the other was Pennsylvania seed; in this comparison the more Northern seed gave nearly as much greater crop as in the other case, but the grain produced weighed four and a-half pounds per bushel more than that from Pennsylvania seed.

Notes on Synonyms:—In sowing the oats the varieties were so arranged that those known to have a resemblance to one another were placed near together. This facilitated comparison. The American Banner and American Beauty are doubtless the same variety under different names. Some authorities give the following as different names for the same variety: Badger Queen, Barley, Clydesdale, Prize Chester, Race Horse, Welcome, White Belgian and White Canadian. Excepting the Barley, the Clydesdale from Thorburn, and the White Belgian, the other varieties appear on our grounds to be the same oat. But here we have the variety Clydesdale from two different seedsmen, with a week difference in time of ripening, and showing different characters in the head; if this is due to the difference in latitude from which the seed came, the question of synonyms can only be answered by at least one more year's work with seed produced here. The fact that seedsmen do not always give the right name adds another difficulty to this work. The White Belgian, if true to name, should have a large open panicle or head; our White Belgian had a closed panicle, with the spikelets all dropping to one side, sometimes called a side-oat, and was undoubtedly identical with White Russian, Baltic White and Japan. The Red Rust Proof and Texas Rust Proof are the same variety, and the Black Prolific and Black Tartarian are identical. Doubtless other synonyms occur, but the evidence is not sufficient to justify positive assertion. There was, this year, no appreciable difference between Early Arkangel, Improved White Russian, Harris, Improved Welcome and Hargett's Seizure, but a single year's trial will not warrant calling them all by one name.

VI.—Variety Test of Wheat.

A variety test of wheat was made in 1891, consisting of a comparison of fifty varieties in field plots, and about an equal number in smaller plots, (of which varieties sufficient seed could not be obtained for sowing large plots.) Also tests of different methods of seeding, of a change of seed from one locality to another, and of the effect of different fertilizers. All of these were reported in detail in Bulletin No. 14 of this Station, for September, 1891, entitled *Wheat.*

VII.—Grass Garden and Forage Plants.

The work in the grass garden has been a continuation of that of the year before. The present report will be mainly on the appearance of those grasses which have been recognized as of some value in Maryland. The following is a list of those that have shown good qualities on our grounds:—Early grasses,—Sweet vernal, Orchard grass, Tall Oat grass, Meadow Foxtail; Medium grasses,—Sheep's Fescue, Meadow Fescue, Tall Fescue, Johnson grass and Bermuda grass; Late varieties,—Timothy and the Bent grasses. Nearly all of these grasses have been very good this season; some exceptions will now be noted: Bermuda grass was inferior to the growth in 1890, but still covered the ground well, this is of chief value as a pasture grass, and for holding hillsides and preventing gulleys; it should not be tolerated near cultivated fields. Timothy appeared well in the spring, and a good crop from the plot was secured, but the main stems soon after died, and the stand next season promises to be very inferior. This was not the result of dry weather, as the bulbs are all plump and full, but many of them are found to be bored through by an insect. At present it is impossible to tell whether the grass was killed by the insect or by other local conditions not yet discovered. All grasses of the Fescue family seem particularly well adapted to this region. The large amount of leaves coming from near the ground make the yield of pasturage great, and the abundance of these leaves produced late in the fall and early in the spring is an additional point in favor of the Fescues. The grass known as Festuca No. 1, obtained from pasture sod on the Cheney farm in Connecticut, is one of the most luxurient, dense sods now on our grounds; this seems to be particularly adapted to pasture lands. A variety of Fescue received from Nevada has not done well here; some seed were produced in 1890, but these failed to germinate the past season. Meadow Foxtail is not adapted to high land; the best natural specimens are to be found near streams and in marshes. Tall Oat and Orchard Grass were exceptionally fine, and have been recommended for use in various parts of the State. The seed of these two, mixed together and applied at the rate of twenty to twenty-five pounds per acre, will be pretty sure to give a good set of grass. Johnson Grass was not as good as in 1890, though it wintered well and showed a fairly vigorous growth in the spring. Canada and Kentucky Blue grasses each gave a fair growth for

these varieties on our soil, but the growth of both was very small, and their only value is in pasture mixtures or for lawns. The Bent grasses, Red Top, Creeping Bent, and Rhode Island Bent, maintained their good reputations as sod makers, and especially is this true in low, wet places; as with all grasses, the richer the soil the better the crop, but the Bents will make a fair growth on land of only medium quality.

Grass Seeding on The College Farm:—The difficulty in securing a good catch of grass on worn lands is one constantly met on the college farm. The hot period occurring nearly every summer is almost sure to kill spring seeding, and lack of fertility in the soil ensuring a good growth in the fall, to protect itself against the winter, causes fall seeding to be extremely uncertain. Early fall seeding in standing corn is practiced in some localities with good results, and this method has been tried here on nine acres of rather light, gravelly land, bearing a crop of corn. The seed used was a mixture of tall oat and orchard grass, at the rate of twenty pounds per acre. To this was added, by separate seeding, about six pounds of red clover per acre. This grass seed was sown late in August last and a fair stand was obtained, promising good results if the winter is not too severe. Eight acres of wheat and barley, directly east of the main college building, have been seeded with the same mixture of grasses, and seven acres in wheat, at the foot of the hill, a little further east, has been sown with timothy. All this was done much later than the seeding in corn. At the north end of the college farm a field of seven acres sown with barley has been seeded with timothy. In these cases barley was sown with the intention of cutting it for forage in the spring and allowing the grass to get an early start. The need of fertilizer in the north field was very apparent, and it was thought best to try stable manure or some material of its kind; accordingly, two carloads of street sweepings were procured from Washington at a cost of $23. per car, including freight. These two carloads contained 54 two-horse wagon cartloads, and this material was evenly spread on five acres, making about ten loads per acre. Coming mostly from streets paved with asphalt, this manure was almost entirely free from brick, stone or other rubbish; it was in a very fine mechanical condition, and while results are not yet apparent, it is believed to be quite a valuable fertilizer. For purposes of comparison the remaining area of two acres in this field was equally divided, and Lot I., dressed with 800 lbs. of coarse ground bone, and

Lot II., with an equal amount of fine ground bone. The history of these two lots of bone was known to be the same, the only difference being in their mechanical condition or degree of fineness. This comparison should enable us to test the lasting effect between the street sweepings and the coarse and fine ground bone.

Clovers:—The medium Red, the Giant Red or Sapling and the Alsike clovers are so well known and appreciated through the State that comments seem unnecessary. The crimson or Italian clover, *trifolium incarnatum*, has been sown for several years past, in various parts of the State, with generally good results, and is now regarded as a very valuable acquisition to the list of forage plants, and also to those especially adapted to "green manuring." It is a very good soiling crop, coming earlier in the spring than either winter rye or red clover and is also good for early pasture. But perhaps it is most valuable for plowing under as a fertilizer. Sown in August or September, it will form a dense green mat that will grow well in the winter, as warm days give it opportunity, and it matures early enough to plow under for planting a crop of corn after it. The benefit of plowing under clover is thus derived, and without the loss of a season for growth. Another very important use is for chicken pasture. Poultrymen often have difficulty in supplying their fowls with green food through the winter; this clover, sown where poultry will have access to it, will supply this want, and very economically. Care should be exercised in sowing this clover not to cover too deeply. Land in good mechanical condition will not need harrowing after the seed is sown. About five acres of our land growing a heavy crop of silage corn this past year was seeded with crimson clover. A cultivator was used to thoroughly loosen the soil, and the seed was sown on the surface between corn rows, on the 30th of August. This produced a very good stand, which is intended to be plowed under in season for a crop of field corn in 1892.

Lucerne, or *alfalfa*, has been sown here thus far with no success. A small plot sown in 1890 grew very well that season, and gave promise of better success than any other plot yet tried. It looked very well in the early spring, received a liberal dressing of kainit, and grew to a height of a foot or a foot and a half; there it stopped and began to die, and at the present time it is doubtful if half a dozen live plants can be found on the plot. This was on good soil, drained and well cultivated in rows.

Lathyrus Sylvestris is the name of a new forage plant recently introduced from Germany, for which the dealer in that country makes many claims. It is said to require only the poorer qualities of soil, and on these to produce wonderful crops for a long series of years. The seeds, resembling small peas, were carefully planted, according to directions, and about one-fifth of them germinated. These made a growth of from four to eight inches the past season. More time is needed before conclusions can be drawn, but it is doubtful if the claims made for this plant can be substantiated in this State.

Unknown Pea:—Another year's experience with this remarkable variety of cow-pea still further recommends it as a green-manuring plant. A piece of land of about three acres, which had recently had a crop of green rye plowed in, was sown with these peas the third of June last. The peas were sown with an Eclipse drill in rows three feet apart, the seed about six inches apart in the row. This required less than a peck of seed per acre. Cultivation was done with a horse, the growth was rapid and vigorous, and on the first of September a perfect mat of vines a foot high covered the ground; so much foliage was developed that great difficulty was experienced in plowing under the crop. The small amount of seed used and of labor required to grow the crop, and the great quantity of green material of a highly nitrogenous character thus obtained, give to this plant a just claim for greatly extended use. We are usually able to save a few seed of the Unknown pea if sown early in the season, but for this State it should be valued only for the growth of vine, and Southern-grown seed must be depended upon, as a rule. Considering the small quantity used, compared with most field peas, this is not a serious objection.

Japan Clover (*Lespedeza Striata*):—This forage plant was first sown here in the spring of 1889 on a pasture, the soil of which was exceedingly worn. This original area has been added to each year, so that we now have six acres seeded with this plant. Being an annual it requires a season long enough to mature its seed, otherwise it must be reseeded each year. Seed has been produced here each year thus far in sufficient quantities to reseed the area fairly well, and no advantage has been derived from sowing additional seed each year on the same land. The naturally reseeded areas appear to do about as well as those assisted by new seed annually. In this section the plant is low and spreading, affording excellent pasturage, but of no

value as a meadow grass. The season of its usefulness is short, however. The plant can hardly be discovered in the pasture until the first of August, and does not usually get large enough for grazing until September; then it grows rapidly, almost regardless of weather, until the first really hard frost, which kills it.

VIII.—The Rotation Plots,—Record for 1891.

The report on the Rotation Plots is one of record only. A description and plan of the rotation to be followed was fully given in the Second Annual Report of this Station. For convenience, the plan of manuring is here repeated. Each half acre is sub-divided into four sections. When in the course of rotation a plot is planted with corn, Section I., receives a dressing of commercial fertilizer; Section II., has an equal amount of plant food in the form of stable manure, (and at the time of bringing wheat into the rotation, this section also has a dressing of commercial fertilizer); Section III. has the same amount of stable manure as Section II., (but nothing else at any time); Section IV. receives no fertilizing material, except the green sod turned under in the rotation. Thus on the six rotation plots the effects of rotation will be observed, without fertilizer, with stable manure, with stable manure supplemented with commercial fertilizer, and with commercial fertilizer alone. During the past two years the plots have all been thoroughly underdrained with two-inch unglazed tile. The drains are thirty feet apart, and each independent and complete in itself. This has improved the mechanical condition of the soil and made the cultivation of the plots more independent of the weather. This last year was the third in the series of six, and therefore none of the plots have given any results showing the effects of a complete rotation.

The following records include fertilizer application, treatment of plots, harvest notes and necessary explanations:

Plot 1:—This plot had medium sod plowed under in fall of 1889, was planted in corn in 1890, and at that time received the fertilizer applied in the rotation to that crop. The corn stubble was plowed under immediately after the crop was harvested, and on April 16th, 1891, the plot was thoroughly prepared with the Cutaway harrow, followed by a smoothing harrow, and seeded with Early Scotch Oats, at the rate of three bushels per acre. No fertilizer was applied. Seed of red clover, at the rate of 16 lbs. per acre, was sown with the oats. The yield of oats was very unsatisfactory, but is accounted for

by the season; the oat crop was nearly a failure in many parts of this State. This is the harvest record:—

Yield (in lbs.)	Section I.	Section II.	Section III.	Section IV.
Grain	56⅞	67¾	74⅜	27
Straw	90	111⅛	134½	150½
Chaff	18⅛	43⅜	60⅛	23½

The yield of grain is largest on the Sections II. and III. These sections received stable manure when planted in corn, and agree in this respect with the results from plot VI., which was sown with oats in 1890. This shows the more lasting effects of stable manure, and will be noticed again in connection with Plot VI.

Plot 2:—Was plowed May first, and after thorough harrowing received the following fertilizers per section:—

Section I., a mixture of 120½ lbs. dried blood, 64¼ lbs. dissolved bone black, 32½ lbs. muriate of potash.

Section II., 2500 lbs. stable manure.

Section III., 2500 lbs. stable manure.

Section IV., no fertilizer.

The stable manure applied to Sections II. and III. was of known composition; it was made by animals kept in water-tight feeding pits for this special purpose, and the quantity and chemical analysis of all foods consumed was known. The commercial fertilizer applied to Section I. contained plant food equal in quantity and chemically equivalent with that in the stable manure applied to Section II. or Section III. The fertilizers were thoroughly mixed with the soil by harrowing. The land being in good condition was then marked off in rows 2 feet 9 inches apart, and Harford county corn sown with the Eclipse drill; this was thinned as soon as it reached a height of about six inches, to a distance of 18 to 24 inches apart in the row.

Yield, Lbs.	Section I.	Section II.	Section III.	Section IV.
Grain	410	272	314	235
Top fodder...	172	148	160	144
Blades	63	54	58	38
Butts	402	326	350	227
Total stover...	637	528	568	409

This is the third plot that has received an application of fertilizer

in connection with a crop of corn. Twice the section having commercial fertilizer has exceeded in yield those sections having stable manure. The yield on these sections of Plot 6 was nearly equal in 1889.

Plot 3:—In grass, receiving no fertilizer. Cut June 4th.

Yield, in Lbs.	Section I.	Section II.	Section III.	Section IV.
Field-cured Hay.	86	41	36	64

Plot 4:—In grass, received no fertilizer. Cut June 4th.

Yield, in Lbs.	Section I.	Section II.	Section III.	Section IV.
Field-cured Hay.	87	45	26	36

Plot 5:—In wheat. Land plowed and harrowed October first, 1890; was in good mechanical condition at that time. October third, sown with Deitz wheat at the rate of five pecks per acre, using a grain drill. Twelve pounds of orchard grass seed was sown on the plot, half at the time of seeding with wheat, and half early in the spring. No fertilizer was applied except to Section II, which received 75 lbs. dissolved So. Ca. rock phosphate and 15 lbs. nitrate of soda. The former was applied at time of seeding, and the latter after growth began in 1891.

Yield, in Lbs.	Section I.	Section II.	Section III.	Section IV.
Grain.........	35	36¼	28⅛	67½
Straw.........	54¾	61¼	57¼	105
Chaff...	11¼	18½	8½	25½

In this case the fertilizer applied had no apparent effect.

Plot 6:—This plot was planted with corn in 1889, and received at that time the fertilizer allowed for it in the rotation. In 1890 it was sown with oats, seeded with red clover, and an additional application of crimson clover seed was made in August to fill up bare spaces. The crop of clover was cut June 4th, 1891, and the second growth was plowed under in September, and the land prepared for and sown with Deitz wheat on the thirteenth of October at the rate of six pecks per acre. Section II, at this time received 75 lbs. dissolved So. Ca. rock phosphate, and as soon as growth begins in the spring it will receive 15 lbs. nitrate of soda. The late sowing was due to a short drouth in September, rendering the land too dry and hard to make a good seed bed, and was thus unavoidable. When sown, the

land was in good mechanical condition and received a seeding of 12 lbs. of orchard grass.

Yield, in Lbs.	Section I.	Section II.	Section III.	Section IV.
Clover Hay....	216	280	286	152
Yield in 1890.				
Oats, grain.....	53¾	55	74	46½
Yield in 1889.				
Corn, grain.....	264½	280½	269	177

The more lasting effects of stable manure, as applied to Sections II. and III., are quite apparent in the above record. The effect of the commercial fertilizer application on Section I., seems to decrease year by year, from the time of its application.

IX.—Potato Experiments.

Beginning with the year 1888, this Station has annually conducted the work of verifying, on a field scale, the conclusion drawn from tests of the effect of different quantities of seed tubes planted, as published in Bulletin No. 2. Each year seed tubers have been used, corresponding in size to those indicated in the bulletin named, and for convenience called A., B., C. and D. Size A. indicates the largest tubers to be found in any numbers in the variety used and planted whole; generally this size ranges from 7 to 10 ounces in weight. B. represents whole potatoes about the size of a hen's egg, usually weighing from 3 to 5 ounces. Size C. is a piece of an average potato, having two or three eyes upon it, and weighing less than an ounce. Size D. is a piece of an average potato, and cut to contain only one eye. In all cases, in the following report, where rows or potatoes are designated by the above letters, it is to be understood as meaning the product of the seed used of the size thus indicated. The practice has been to avoid differences in the quality of the soil by planting in sections of four rows each. Each section contains one row of each method of seeding. The hills in every case were two feet apart, one piece or one whole tuber, according to the row, being the seed in each hill. This duplicating of sections is in fact a multiplication of tests, and allows of averages being taken that fairly represent the results. During the season of 1891 the experi-

ment was duplicated, as in previous years, by using both an early and a late crop, and as two varieties were used in each case, we have a comparison of four varieties. The seed potatoes, for both early and late crops, were obtained from Aroostock county, Maine. The land for the early crop was carefully prepared by plowing and harrowing on the 8th and 9th of April. Forty rows, 326 feet long, were laid off with the disc marker. Twenty of these were planted April 10th with Early Rose, and the remainder with New Queen; each in sections of four rows each, as described. The acre of land received 700 lbs. of dried fish sown in the row, and 300 lbs. muriate of potash, sown broadcast. A heavy shower, followed by drying weather, baked the ground so hard that many of the hills failed to come up, although the crust was somewhat loosened with a smoothing harrow. The advantage of the larger quantity of seed was very apparent at this stage, giving greater vigor of shoots, forcing their way out and securing a much better stand. Such cultivation and weeding as was necessary was well performed. The digging and weighing was finished the 12th of September, the potatoes being sorted into merchantable and unmerchantable, and the weights of each also taken. With the exception of dates and the land used for the experiment, the foregoing description of the early crop will apply to the late one. The season and land were still more unfavorable for the late grown crop, however, and consequently there were even more missing hills. The late varieties were planted on separate areas of land, one-half acre of each. Dakota Reds were planted on the first half acre, which was 198 feet long by 110 feet wide, giving room for eleven sections of 99 hills to a row; these were planted June 29th, and harvested November 5th. The second lot was 218 by 100 feet, giving room for ten sections of 109 hills length; this was planted with Early Harbinger on June 30th, and harvested the 12th of November.

To illustrate this subject, photographs were taken, and these are reproduced by accurate engravings on pages 372 and 373. These represent the seed tubers as planted (Fig. 1), the appearance of the field at different stages (Fig. 2 and Fig. 3), and the crop from one row of each method of planting, assorted as merchantable and unmerchantable. All are from the field of New Queen potatoes. The letters A., B., C. and D. are used as explained above and as in the following table.

The crop of late potatoes was a failure; while this does not effect the comparison between methods of seed cutting, it makes the results very unsatisfactory from a practical standpoint. Table V. gives the record of product for the year's trial.

TABLE V.

COMPARATIVE PRODUCT OF POTATOES, PER ACRE, IN BUSHELS, FROM THE FOUR DIFFERENT FORMS OF SEED PLANTED.

VARIETIES, ETC.	FORM A. LARGE. WHOLE POTATOE.	FORM B. SMALL. WHOLE POTATOE.	FORM C. PIECE AS USUALLY CUT.	FORM D. PIECE CUT TO SINGLE EYE.
Early Rose.	Bushels.	Bushels.	Bushels.	Bushels.
Total product.	230½	192	104	72
Merchantable tubers	117½	104	64	52½
Seed planted	64	26	7	3¾
Product good over seed	53½	78	57	48¾
Per cent. missing hills	32.14	39.63	47.48	48.95
New Queen.				
Total product	288	214½	124	91
Merchantable tubers	142	131	81	52½
Seed planted	78	31¼	9¾	4¼
Product good over seed	64	99¾	71¼	48¼
Per cent. missing hills	6.62	12.14	31.15	34.11
Dakota Red.				
Total Product.	131	97	56	47½
Merchantable tubers	74½	62½	44	34½
Seed planted	77½	31½	10¼	5⅓
Product good over seed	3‡	31	33¾	29⅜
Per cent. missing hills.	7.71	9.64	51.14	85.76
Early Harbinger.				
Total product	79½	61½	19	11
Merchantable tubers	36	34½	7	6
Seed planted	64	25¼	7	4
Product good over seed	28‡	9¼	0	2
Per cent. missing hills	26.88	31.92	64.67	89.63

‡Merchantable less than seed planted.

Fig. 1.

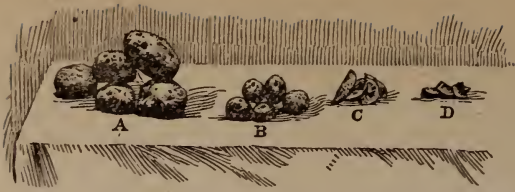
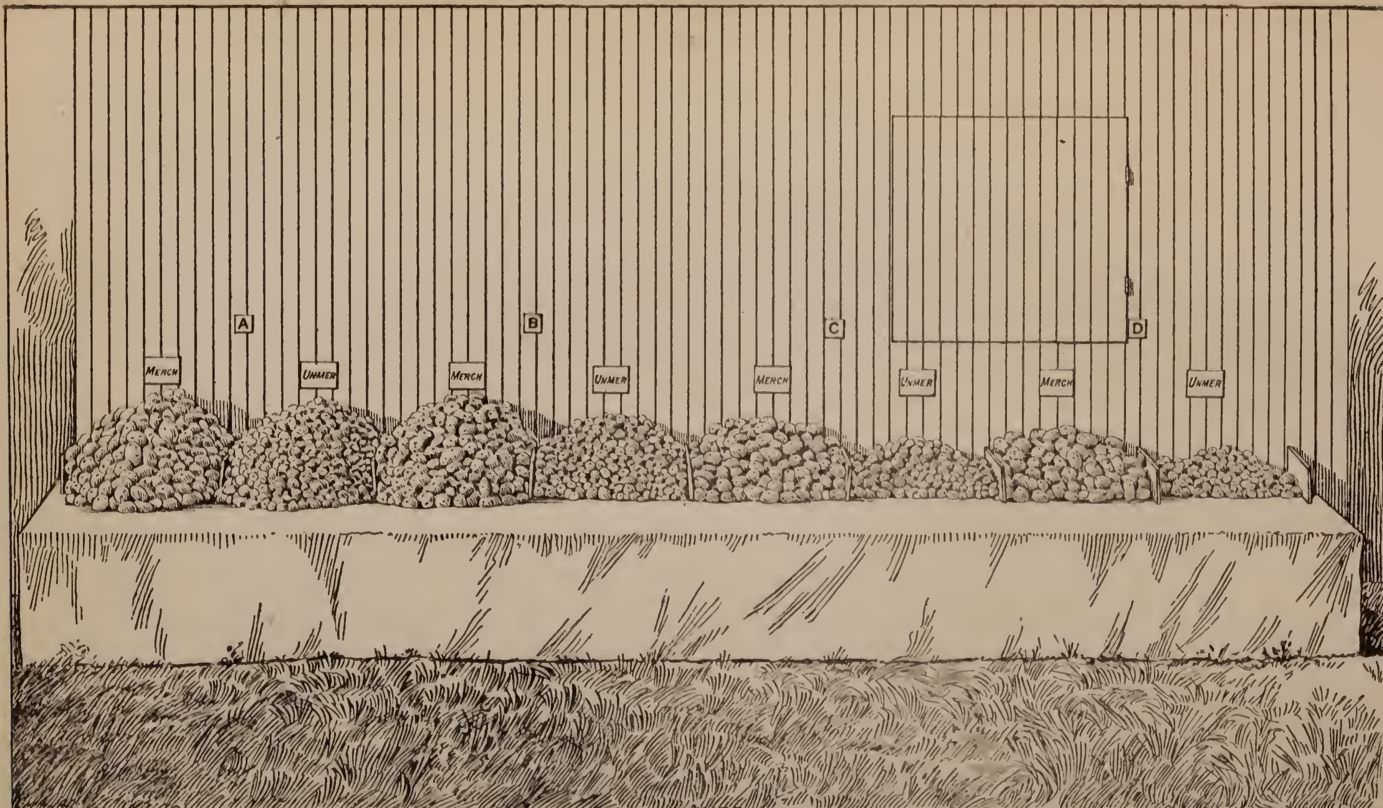


Fig. 2.

Fig. 3.


A
B
C
D
MERCH
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UNMER
MERCH
UNMER

Results of Potato Experiments:—The results of three year's work in this line of field verification on the question of the quantity of seed tuber which should be used, clearly establish certain conclusions which may be thus stated:—

1st:—The "stand" or number of growing hills bears a close relation to the quantity of tuber placed in the hill. Invariably the smaller the cutting the greater the percentage of missing hills; cutting to a single eye will materially affect the yield in an unfavorable season by reason of the missing hills.

2nd:—The total yield is proportional to the amount of seed used; other things being equal, the greater the weight of seed tuber planted the greater the total product.

3d:—The ratio of merchantable to unmerchantable tubers is very nearly alike in forms B., C. and D., but greatly decreases in form A., being often less than 50 per cent., as compared with 60 to 65 per cent. in the others. In other words, excessive seed as in the form A. causes a great production of small potatoes.

4th:—The merchantable yield in excess of seed planted has generally been greatest in form B. Yet in some cases the form A. has given the best net result.

5th:—The increased cost of seed for form A., and the quantity used per acre, is usually too great to be offset by the increased yield, while the form B. is readily obtainable at common price, and the quantity used per acre (25 to 30 bushels) is only about one-third that required for the form A.

6th:—The question of different distances between hills could not enter into this comparison.

X.—Seed Potatoes Grown in Maryland and Vermont, Compared.

The common custom among progressive farmers of changing their seed potatoes frequently, led to testing the comparative products from Southern and Northern grown seed, under identical conditions. For the past three seasons an exchange of seed has been made with the Vermont Agricultural Experiment Station, and for the purpose of eliminating any variety differences and obtaining average results, several varieties have been used each year. Sufficient seed tubers could not be obtained to plant them whole, and for uniformity all

were cut to pieces of the same size, containing from two to four eyes. The difference in aggregate weight of seed planted of the different varieties was less than one-half pound. Land of uniform quality was used, and the two lots of each variety were planted in contiguous rows. Twenty-five hills of each lot of each variety were planted the 27th of April, but many failed to grow, especially of the Maryland seed. Treatment as to plowing, fertilizing and cultivating were identical. The potatoes were dug August 27th, and assorted and weighed at that time. The yields are given in Table VI., calculated per acre for the number of hills present at time of digging.

Table VI.

Comparison of Potatoes from Northern and Southern Seed.

Station Number and Variety.	Yield per Acre, in bush., from Maryland Grown Seed at Maryland Expt. Station.			Percentage of Missing Hills.		Yield per Acre, in bush., from Vermont Grown Seed at Maryland Expt. Station.		
	Large.	Small.	Total.	Md. Seed.	Vt. Seed.	Large.	Small.	Total.
28 Stray Beauty..........	51¾	26	77¾	72	20	118	34½	152½
38 Dakota Red.......	....	....	....	96	8	139	20½	159½
45 Monroe Co...	56½	54¼	110¾	60	28	140½	20	160½
46	57	26	83	44	12	112½	23	135½
55 Rural Blush...........	89	28½	117½	8	0	101	40½	141½
71 Delaware..............	96	36	132	48	16	126	23	149
102	70½	30	100½	32	12	143½	21½	165
Average, 7 Varieties.......	60	28½	88½	51.4	13.7	125½	26	152

Results:—1.—The vitality of the seed potato is impaired by the moist and relatively high temperature of a Maryland winter; this is seen by the percentage of missing hills, averaging nearly four times as many in the Maryland seed as with the Vermont seed.

2.—The yield of merchantable tubers is, in every case, greatly in favor of Vermont grown seed. The average of the seven varieties from Vermont seed is more than twice that from Maryland seed.

3.—The quantity of small or unmerchantable tubers averages nearly ten per cent. *greater* with the Maryland seed, while the average total product of Maryland seed is only 58 per cent. that of Vermont seed.

XI.—Miscellaneous.

Sugar Beets:—An attempt was made to grow an acre of beets for stockfeeding. The soil was a medium clay, well dressed with stable manure; about eight cords per acre were plowed under. Considerable difficulty was experienced in securing good seed. The first was sown May 11, but largely failed to germinate; it was resown June 1st, with seed from another source. The percentage of germination the second time scarcely exceeded the first, and the probability of failure appeared from the beginning. Enough plants were secured to fill out by transplanting the rows on about one-fourth of an acre, but the only time at which it was possible to do this was so late that none of the beets reached a large size. Good beets were finally harvested sufficient to make a comparative feeding test with ensilage, which it is intended to carry out this winter.

It would have been more economical in raising the above crop to have sown the seed quite early in a hotbed. The transplanting from the hotbed to the field would take no more time than the necessary hand-weeding when grown in the field, and all risks of too thin seeding would be thus overcome. On very large areas this might be impracticable, but where land has inherited a generous supply of weed seed, much hard work must be done to keep the weeds from smothering the young beets.

Flax:—The culture of flax is almost entirely confined in this country to the North and West, and in many cases it is there grown only for its seed, the fibre being wholly neglected. The successful culture of flax for fibre requires considerable skill, a rich soil, fine and free from weeds, and also more care in weeding, harvesting and preparing for market than farmers generally find it profitable to give. The use of improved machinery in the handling of flax will doubtless reduce the cost of growing and perhaps make it a profitable crop in the East.

To stimulate experiments in flax culture, the Department of Agriculture at Washington sent to various sections sufficient flax seed to sow one acre of land. The land used at this Station was a level plot

of medium clay, not very fertile. The land was plowed May 1st, one-half was covered with a good dressing of eight cords of stable manure per acre; the other half acre received 250 lbs. of dried fish. The land was very carefully prepared with harrow and roller. The seed was sown May 5th with the Superior grain drill, at the rate of two bushels per acre. Germination and growth were good and an average height of between two and three feet obtained, some of it being over three feet. No means of retting and separating the fibre were available, and consequently no determination of the quantity or quality was obtained.

Feeding Experiments:—During the past year a series of pig feeding experiments, under the supervision of the writer, have been concluded, and the record of the same published as Bulletin No. 12, of this Station, dated March, 1891. Experiments in feeding Hereford steers have also been carried on. The questions of digestion and the chemical aspects of this work, will be fully reported upon by the Station Chemist, herewith. The other considerations in the same connection, such as the relations of growth and beef production to the different rations used, with notes on live weights, food and manure, are reserved for publication with the record of other work of similar character, now in progress.

Preservation of Fence Posts:—Upon the last page (76) of the First Annual Report of this Station, there is a record of setting the posts in three different lines of fencing, and posts of three different kinds, in ten different ways, in each line, as to preparation to ensure durability. Those posts were of round cedar, sawed chestnut, and sawed oak, well seasoned, and all set in May, 1888. Of course no report can be made yet upon the results of that trial.

In November, 1891, a similar experiment was begun, of which the primary record is as follows:—Thirty posts were planted, in sets of five, all being hewn from the same log, an oak tree cut a year previous. The posts were as nearly identical as possible, were eight feet long, set in holes three feet deep, and these were dug from twelve to fifteen inches in diameter, and afterwards filled with the same soil, rammed tightly at every post. The line of wire-fencing in which these posts are set is on the Northern boundary of the College Farm, beginning at the turnpike, near the bridge over Paint Branch, and running Westerly to a ravine through which flows a small spring

branch. Beginning at this ravine and following the line described Eastward, the special treatment in post setting commences with the fifth post from the ravine. The six sets of five posts each were prepared as follows, before being planted:—

1. The first set had their entire surface covered well with crude petroleum, applied with a brush.

2. The next set, Eastward, were similarly covered with the same oil, from the lower ends to a line about six inches above the surface of the ground, as planted.

3. The third lot of five were painted entire with creosote oil, instead of petroleum.

4. In this set the posts were painted with creosote oil, but only as high as those in set No. 2.

5. These posts were entirely covered with "Cable Coating," a material of about the consistency of common axle grease, furnished by the Baltimore United Oil Company, for this trial.

6. The easternmost set of five posts also received a dressing of Cable Coating, extending to a line six inches above the ground.

These posts carry four wires, fastened by staples, and the posts were set under like conditions in every respect, except as to the preservatives applied to them, as described. In the same fence line, on either side of these thirty posts, a few others were set, at the same time, just like the thirty, but without the application of any preservative.

A. I. H.

REPORT OF THE HORTICULTURIST.

By Thos. L. Brunk, B. S.

The work of the Horticultural Division of this Station during the year 1891 has been in most respects encouraging. While a good deal of experiment work has been done, as shown upon the pages following, much of the time has been spent in gathering material, planting and preparing generally for future work.

About twenty acres of land in all are occupied by this Division, including a variety of soils, most of it a clayey loam. The location and character of the test orchard has been heretofore described. On another part of the College Farm, about six acres have been assigned for horticultural work. This piece is on a gentle westerly slope, well protected by a natural forest. About one acre is gravelly, and the remainder a sand-clay loam. The vineyard and nursery have been located here, also a new orchard, mainly for a *prunicetum*, or study of the plum family, and further tests with small fruits and vegetables.

The apple orchard of the College Farm, situated on its western boundary, just north of the county road, has received a good deal of attention during the year. This occupies about four acres, now in grass, and the trees are of middle age and in a good state of growth and vigor. The past season the varieties have been identified, and it was found that the orchard contains 9 Winesap, 9 Early Harvest, 10 Smith's Cider, 10 Limbertwig, 4 Siberian Crabs and 4 trees of a yellow apple not known. This orchard was carefully pruned, the borers dug out, the old bark removed with scraper, and a preventive wash was applied to the bodies and main limbs on the first of May. This was made of soft soap and salsoda (carbonate soda)—one-half pound of the soda to a pail of soap; water was added till it had the consistency of thick paint. It was applied with a heavy brush, such as used in sweeping city streets. Before removing the borers, a basin was made with the spade about each tree, and the wash was applied to the bottom of it. This orchard made a fine growth and bore a heavy crop during the past season. Here also the spraying tests were made, which are described later in this report.

I.—Test Orchards.

The trees of this orchard have not grown very well, and they were not pruned according to my ideas when set out. Our effort the past season was to get this orchard into a vigorous growing condition, and to give as good shape to the trees as the circumstances would admit. A year ago, when the writer took hold of this work, the orchard was first thoroughly fall-plowed—plowing away from the trees to level the ground. All the vacant places were filled in, and several poor trees were also replaced by better ones. This has been done annually from time of first planting. During the late winter the trees were cut back considerably to give them vigor and to lower the heads. A few of the pear trees having long thin bodies with a small stunted top, four feet from the ground, were summarily cut off to within sixteen inches of the ground. The result is that adventitious buds sent out several branches from the remaining stem that have made from five to seven feet of growth. This was done with only two varieties—Rutter and Flemish Beauty. These trees made four times the growth of those with heads four feet above the ground, and will make fine specimens of pyramid trees from the ground up. I find that many planters have made the great mistake of not pruning back their trees to branch within a foot of the ground; and if such orchards are not more than three years old, or the stems not over two inches in diameter, they can be headed back yet with great advantage. Peaches and most plums cannot be headed back in this way with safety, after the second year. It is not uncommon to find six-foot growths among the young peach trees that were "headed back" severely last winter. Those that were one-sided are now rounded up and symmetrical.

In the early spring the cutaway harrow was started, and when it had passed over the orchard twice the surface was left in a fine condition. This is the best and most rapid cultivator we have used for this kind of soil. The cutaway has a tendency, however, to leave a ridge of soil on each round, and to level this we alternated with it the use of the common spike harrow. Level culture is best. The cutaway harrow was passed over the orchard at intervals of about ten or twelve days until September, when the surface was in excellent condition to receive rye. This was sown to prevent winter washing and leaching, the escape of nitrogen, and to form an excellent green manure to be turned under in May.

Young orchards need good cultivation. The owner should constantly aim in tilling an orchard, especially when young, to keep a

blanket of loose surface soil under and about his trees. This conserves moisture, sets free more plant food and keeps down weeds, the greatest enemies of a young tree, because they use and evaporate the water needed by the tree.

II.—Spraying Experiments.

Our work in spraying, the past season, had a three-fold purpose. The first was to combine such preventives as to be able to cope with a number of insects and fungi that infest and destroy the apple crop from year to year. The second was to find some remedy for diseases not heretofore treated in this way. The third was to repeat some tests made elsewhere, to note if we could obtain similar results. The season was unfavorable for such trials, because of many showers and heavy rains. Frequently these came just after we had finished a piece of spraying, and washed it off, thus materially changing the results. Moreover, at times when further applications should have been made, the weather prevented.

Spraying Apples:—With apples we tried some mixtures to see if all insects,—mandibulate or biting, as well as haustellate or sucking,—which work upon the leaves, buds or fruit, cannot be either destroyed or prevented from laying eggs, while at the same time the applications prevent fungus growths. Prof. Gillette, of Iowa,* has made tests combining the arsenites with sundry mixtures, soapy, resinous, sulphate copper, bordeaux, carbonate copper and kerosene emulsion. He found that when added to mixtures containing soap and sulphate copper, the injury to the foliage was greatly increased over that in which the arsenites were used with water alone. Paris green and London purple, with the Bordeaux mixture, proved to be less injurious to foliage than when used with water alone. He says:† "Of all the substances I have used in combination with the arsenites, * * * none can be compared with Bordeaux mixture for the prevention of injury to foliage." With ammoniacal copper carbonate, arsenites did less injury than with water alone. With kerosene emulsion he was unable to find a method by which arsenites could be mixed so as to make a workable mixture. Some of these tests I have repeated, with results that are partly corroborative of those reached by Prof. Gillette, and partly varying from them.

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*Bull. 10, Iowa Expt. Station.

†Ibid., p. 416.

The apple trees selected were nearly all of the same size and vigor. Two trees were selected for each test—one of Winesap and one Limbertwig. In five of the tests, the trees were sprayed before the buds opened, with a solution made by dissolving one pound copper sulphate in 25 gallons of water; to this we added 3 ounces of London purple. This is known as the "Winter Treatment," and is applied to destroy all spores of fungi adhering to the exterior of the tree, and with the London purple added, to kill all bud worms that may be hatching. This was applied the eleventh of April. Owing to bad weather all the test mixtures were applied but three times, the 7th and 27th of May, and the 17th of June. The first was as soon as the fruit was set and all the blossoms had fallen. In each case the spraying was done in the afternoon. The comparative results are given in Table No. I. Early in the season the apple tree aphis (Aphis mali, Fabr.) became quite abundant on all the trees. A few nests of the Tent Tree Caterpillar (Clisiocampa Americana, Harris) appeared. The Wooly louse (Schizoneura lanigera, Hausm.) was found more or less abundant on nearly every tree, especially about fresh wounds. This is the same louse that often attacks the roots. The Codling moth (Carpocapsa pomenella) did not seem to be very numerous, as shown in the table following, under check trees. Many of the young fruits were stung by the apple curculio (Anthonomus quadrigibbus, Say.) causing them to drop prematurely. There were a few Bucculatrix larvæ and occasional work of the apple leaf skeletonizer (Pempelia Hammondi), and the Leaf Crumpler (Phycis indigenella). The Buffalo Tree-hopper (Ceresa bubulus) was also present, but not in considerable numbers. There was a little work found this fall of the Appletree Pruner (Elaphidion villosum), but not enough to do any appreciable damage. There were no canker worms or bark lice found during the season. Both the Round-headed (Saperda Candida) and the Flat-headed (Chrysobothris femorata) borers were in nearly all the trees, and they were, of course, specially treated.

Of the fungi that appeared during the season, the Leaf blight disease (Entomosporium maculatum) was the most prevalent, but it was not serious even on the unsprayed trees, except with a few pear trees, which, because of it, dropped all their blossoms and set no fruit.

In our young test orchard, on the part least drained, many trees suffered from Apple Leaf Rust (Rostelia pirata), but it was hard to find specimens of it in the old orchard, in which the spraying was

done. There was no sign of Apple Scab (Fusicladium dentriticum), or Bitter Rot (Glæosporium fructigenum), although I found a few spores of the Apple Scab on some old apples that hung upon the trees till spring.

TABLE I—SPRAYING MIXTURES COMPARED.

Two Apple Trees in each trial—Limbertwig (L.) and Winesap. (W.)

No. of Expt.	Mixture Used.	Tree.	Large Perfect Fruit. No.	Large Perfect Fruit. Bus.	Large Fruit Injured by Mixture. No.	Large Fruit Injured by Mixture. Bus.	Small Perfect Fruit. No.	Small Perfect Fruit. Bus.	Small Fruit Injured by Mixture. No.	Small Fruit Injured by Mixture. Bus.	Number of Wormy Apples.	Leaves Injured by Mixture.
1.	Ammoniacal Copper Carbonate and Paris Green.	L. W.	74 1077	½ 4½	577 14	4½	 342	 1	175	½ ...	17 92	Per ct 65 15
3.	Copper Carbonate and Carb. Ammonia with Paris Green.	L. W.	891 1145	4½ 3¾	841 745	4½ 2¾	137 280	½ 1	203 320	¾ 1½	55 30	35 05
6.	Carbonate Copper and Carb. Ammonia alternated with Paris Green.	L. W.	135 548	1 2¼	1217 1034	6¾ 4	 129	... ¾	392 493	1½ 1½	90 47	20 05
7.	Kerosene Emulsion, Copper Carbonate and Paris Green.	L. W.	 273	.... 1½	534 789	3¼ 3½	... 83	.... ¼	120 200	½ ¾	40 50	16 03
8.	Improved Ammoniac'l Copper Carbonate, (without Paris Green).	L. W.	28	1/5	714		....	....	130	½	45	20 .....
5.	Carb. Copper and Carb. Am. with Paris Green, but no Winter treatment.	L. W.	90 1545	½ 6½	799 785	4¼ 3¼	26 395	1/10 1¼	368 410	1¼ 1¼	14 40	25 01
0.	Check Trees receiving no treatment.	L. W.	886 1486	5¼ 6	.. . .	....	175 2[illegible]4	¾ 1	....	....	153 186	....

Note:—The spraying, as a whole, does not appear to have been profitable, except as to insecticides. The Table above shows that the "check trees" which were not treated, produced more perfect fruit, both large and small, than the trees which were sprayed; but the latter had, on an average, only about one-fourth as many wormy apples.

H. E. A.

From these notes on the observations made, it can be seen that our results from spraying, this season, cannot be claimed as any evidence that the mixtures used would prevent some of the most severe diseases that often attack the apple.

The different mixtures used for spraying will now be described:—

Ammoniacal Copper Carbonate, with Paris Green:—It was desired to test this fungicide with an arsenite to note what effect the mixture would have, if any, on the foliage, believing that if not injurious to the foliage it would be a good combination to prevent both the fungus diseases of the apple and several insects that feed upon the leaves and the codling moth. Three ounces of the Copper Carbonate were dissolved by three pints of ammonia, using a gentle heat, and added to fifty gallons of water. In every case we used fifty gallon Kerosene barrels, with 2½ inch hole for the pump hose to enter, and another hole 1x4 inches through which was introduced a wooden agitator. I prefer the wooden home-made agitator to the iron one offered in the market. After reaching the orchard one-quarter pound of Paris green was added to the mixture, and after thoroughly mixing it, the spraying at once began. The barrel full of this mixture costs 48½ cents. The results show that the Paris green was very quickly dissolved, as the foliage of both varieties were badly injured, but much less on the Winesap than on the Limbertwig. Most of the leaves on the sides of the Limbertwig were destroyed, while those in the top were much less injured. This tree also dropped much of its fruit prematurely. The fruit was very lightly affected on the Winesap, but more on the Limbertwig. The injury referred to and attributed to the action of the mixture was simply a rusty coating that appeared on parts of the surface of the fruit. The injury was quite superficial, not going deeper than the thin outer skin, and simply injured the appearance, but not the flesh of the fruit. In fact, most of these fruits would have brought nearly as good a price in the market as the smooth ones. The Limbertwigs have naturally a brown or rusty cavity,* and probably some of those classed with the injured were not rusted by the mixture. No doubt, however, that most of them were, as specimens were seen by Profs. Galloway and Goff, who pronounced it to be injury from the mixture. This mixture seems to be too alkaline. In our work it was no more

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*American Pomology, Warder, p. 516.

efficient and did more injury to the foliage than the mixture next described. Moreover, this mixture costs nearly twice as much as the next one described. Finding that our results agree with those of Prof. Maynard at the Mass. Experiment Station,* I am doubly confident that the mixture should *not* be recommended, although Prof. Gillette seems to have reached more favorable results.

Carbonate Copper and Carbonate Ammonia, with Paris Green:—This mixture was tested for the same purpose as the last. It is made by dissolving one pound of pulverized carbonate of ammonia in a gallon of water, and then adding three ounces of copper carbonate. It is best to heat to 100 degrees Fahr. Add this to fifty gallons of water, and when in the orchard, put in one-quarter pound of Paris green, and begin spraying at once. The fifty gallons cost 25½ cents. The cheapness, efficiency and ease of preparation, commend this mixture for general use. It does not stick to the foliage as well as the Bordeaux mixture, but it is easier to handle and much cheaper. It does not clog the nozzles when spraying, and does not stain the fruit. It did but little damage to the Winesap foliage and caused no premature dropping of the fruit. This tree was quite healthy throughout the season. The Limbertwig was considerably injured by the mixture, causing the leaves to dry at their edges and often destroyed the whole leaf, especially on the lower parts of the tree, where they received the drip from the leaves above. Some fruit fell prematurely, both from the injuries of the mixture and curculio stings. The skin of the fruit was not injured as much by this mixture as by the one preceding, and others. It was tried alone without the "winter treatment," and the results are shown by Experiment 5, in Table I. There was nothing to show any gain from the use of the "winter treatment" over the summer treatment alone. The reason is no doubt due to the fact that there was no active disease present this year. But from past experience, and that of many other experimenters, it is to be considered an important part of a season's spraying.

The third test made with this mixture was to leave out the Paris green and spray the trees alternately with Paris green in water and the Carbonate Copper and Carbonate Ammonia mixture. The Paris green was in every spraying applied about two hours after the Carbonate Copper and Ammonia mixture, giving time for the leaves to dry off. The fruit seemed to be more damaged, and the leaves affected about the same as when the two solutions were applied mixed together.

*Bull. 11, Mass. Hatch Ex. Sta., Jan., 1891.

Kerosene Emulsion, Copper Carbonate and Paris Green Mixture. With this combination the culturist is able, I feel confident, to cope with nearly all the insects and fungi that affect both fruit and leaves of the apple and the pear. It took several laboratory tests before a method was found of mixing these ingredients so as to make a preparation which could be easily sprayed. Making the Kerosene Emulsion first and then trying to mix in the other two ingredients, resulted every time in the production of clotted masses that would not pass through the sprayer. Finally I obtained a good working mixture by first dissolving three bars (about 27 ounces) of Lenox soap in three gallons of hot water; this was poured into a barrel or half-barrel, and to it was first added one pound of Carbonate Copper and 2½ ounces of Paris green. The whole was then thoroughly mixed with a large Lewis combination syringe by spraying it back into the barrel repeatedly. The soap is a good suspender of both the Carbonate Copper and Paris green. Six quarts of Kerosene oil was finally added and thoroughly churned with the syringe till well emulsified into a green, milky mixture. This was then diluted to 28 gallons and sprayed upon the trees. The Paris green remained suspended very well and did not need as much agitation as when sprayed with water alone. The cost was about 51 cents for 28 gallons.

While the table does not show as good results with the fruit as with other mixtures, yet the foliage was affected less with this than with any other. It is one of the best to use if trees are infested by sucking and biting insects as well as by fungi, at least for two applications in the early part of the season, before the fruit is half grown. The mixture is not a pleasant one to handle, as it sticks to everything; it should not be used just before apples ripen, unless the Kerosene is left out. We used it once on some trees in this way and it worked admirably. Another season I will use it with but half the quantity of Kerosene, and believe the effects on lice will be good enough.

Improved Ammoniacal Copper Carbonate:—Our Station Chemist made some tests which showed that in the presence of another alkali it took less Ammonia to dissolve the Copper Carbonate used in the Ammoniacal Copper Carbonate mixture. He found that it required about five pounds Sodium Carbonate (Salsoda) with four gallons of hot water to dissolve three ounces of Copper Carbonate with one pint of Ammonia. This forms a blue liquid resembling the Ammo-

niacal Copper Carbonate solution, in which Ammonia is used alone as a solvent. Dilute this to 50 gallons. We found that as high as a pound of Pyrethrum could be easily mixed and sprayed with this mixture. Paris green was not used with this mixture, as it was found to dissolve in it very readily and would cause great injury to the foliage.

This improved mixture costs but 31 cents per fifty gallons, while the old Ammoniacal Copper Carbonate mixture costs 48½ cents, and the improved is less injurious to the foliage.

Miscellaneous Spraying:—We sprayed Water Melon, Cucumber, Musk Melon, Pumpkin and Squash vines on the first of August with a medium strength *Bordeaux Mixture.* This was made by slaking 4 pounds of quick lime in a wooden vessel, and then adding water until reduced to a "milk of lime;" in another wooden or earthen vessel, 4 pounds of Sulphate of Copper was dissolved in hot water; when cool these two were mixed, being well stirred at the same time. This was then diluted to thirty gallons, and was ready for use. Its cost, made as above, was 29 cents per 30 gallons. The single spraying produced a marked difference in health between the vines sprayed and unsprayed. The leaves of the former were much longer retained, and the latter, in some cases, produced no fruit. Those left unsprayed were badly attacked by a fungus, known as *Glaeosporium lindemuthianum* (Sacc & Magnus). This begins on the leaves next to the roots, and gradually involves every leaf till the tips of the vines are reached. I have seen whole fields of twenty to thirty acres swept away by this fungus. The disease can be easily prevented by a timely application of the reduced Bordeaux mixture, as given above. The oldest leaves need the most thorough work. Three sprayings is enough, and in most seasons two will probably be found sufficient. The first should be given when the earliest fruit is about a third grown, and a second may be three or four weeks later. Prof. B. T. Galloway recommends* for this disease *Eau Celeste.* This is made by dissolving one pound copper sulphate in one pint of ammonia; add three gallons of water and let stand till settled, when the clear liquid above should be poured off to get rid of the sulphate of ammonia which may burn the leaves. This clear blue liquid should be diluted with 22 gallons of water.

Our Musk Melons and Cucumbers were also affected by some fungi which were not determined. The spraying, however, greatly pro-

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*Bull. 8, Botanical Div., Dept. Agr., 1889, p. 64.

longed the life of the foliage, and hence did much to mature perfect fruits.

This work was done with a Japy knapsack sprayer, which enabled us to walk about among the vines. Growers would be able to save in some seasons over half of their vine crops by a small outlay for sprayer and material.

Spraying Tomatoes:—Our Tomato test plots were seriously injured by a fungus known as *Cladosporium fulvum* (*Cke.*), which forms olive green velvety patches on the underside of the leaves, causing them to die at those spots. The disease gradually spreads till the whole leaf is destroyed. The oldest leaves are affected first, and they gradually die and drop or shrivel up till the stems are entirely defoliated.

This disease has been especially destructive to vines grown under glass.* In 1889, Col. A. W. Pearson† sprayed some plants with the Bordeaux mixture and others with the Carbonate Copper mixture. The first, he claims, burnt the foliage, and the second was protective against the disease. Our results were quite the reverse. The vines we sprayed with Bordeaux mixture (strength as given for melon spraying) were not injured, although some of them received the concentrated part of the mixture in the bottom of the barrel. But these vines were on high ground, and those beside them did not show any signs of the above disease. Our test plots were over a quarter of a mile from the above plants and on low ground. We sprayed these vines three times with the Carbonate of Copper and Carbonate of Ammonia mixture already described, but using *no* Paris green. The first spraying was done the 7th of August, when but few specimens of the fungus had appeared. The other applications were made the 13th and 24th of August. Half of each plot of ten vines was sprayed and the other half left untreated, for comparison. The work was done with the Japy knapsack sprayer with Vermorel nozzle. The spraying seemed to check the disease somewhat, but it soon began to spread as rapidly as before. A week after the third spraying it was difficult to note any advantage which had been thus gained. If the spraying had been started earlier in the season and two or three more applications had been made, better results might have followed. When the disease once gets a foothold, it is useless

*See account of Marcius Wilson, Vineland, N. J., in Report Sec. Veg. Pathol. 1888, page 347. †Bull. 11, Sec. Veg. Pathol., U. S. Dept. of Agr., page 47.

to spray unless it is done every three or four days. The first two sprayings beginning after fruit is "set" should be made with the "medium" strength Bordeaux mixture—lime, 4 pounds; sulphate copper, 4 pounds; water, 30 gallons. No field should be planted with tomatoes that had diseased plants upon it the year before. In fields on the Eastern Shore that were visited, no vines were affected with this disease, but growers should keep a close watch for its appearance.

Spraying the Strawberry:—On the seventh of August we cultivated and cleaned up our strawberry test plots, and finished the work by spraying a part of them with the Bordeaux mixture (medium strength), for the leaf rust or blight (Sphærella fragariæ). Six days later the same vines were sprayed with the Ammoniacal Copper Carbonate solution, previously described. These two applications proved to be very beneficial. The plants sent up a new healthy growth, which they preserved until frost. There is no variety of strawberry that is totally exempt from the attacks of this parasite, and some of our best varieties are cut down by it in the midst of the fruiting season, destroying half of the crop. The Bordeaux mixture is not so easily washed off as other mixtures, and hence acts as a preventive of the disease for a longer time. Three sprayings with it in the summer and fall, the first as soon as fruiting has ceased, and the other two at intervals of three weeks, and one spraying in the spring with the same mixture, before the flowers appear, will afford nearly a complete protection against this disease.

Spraying Blackberries:—The dreaded red rust (*Caeoma nitens, Schw.*), which was prevalent in our test grounds last season, we tried to prevent this season by spraying. Before the foliage appeared, on April 9th, one-half of each plot was sprayed with the mixture made by dissolving one pound sulphate copper in 25 gallons of water. This is known as the "Winter Treatment." On the second of May, after the leaves had appeared, a single plant in the Wilson Early row was the only one that was affected in the whole test ground. It was dug up and burned. After the blossoms had fallen, May 13th, the vines were sprayed with our Improved Ammoniacal Copper Carbonate solution. This burnt the foliage somewhat, but did not do much injury. The vines were not sprayed again until fruiting had ceased. On August 7th the vines were sprayed with the old Ammoniacal Copper Carbonate mixture. The leaves at this time

began to show a little of the disease. Another application of the same mixture was made the 24th of August. A later inspection showed that there was very little, if any, difference between those treated and those untreated. This work seems to be farther proof of what has been shown by Prof. B. T. Galloway* in his investigation of the perenniality of the mycelium of this fungus in the canes. Mr. F. C. Newcombe, who assisted Prof. Galloway in this work, found that the mycelium lives on the interior of the canes from year to year, and Prof. Galloway concludes that it is doubtful if spraying alone to destroy the spores "will pay in the end," since the disease, when once within the plant, will continue to grow, throw off spores and undermine the life of the plant. He says also in the same place, "after all, it seems that the only practical and efficient method of dealing with this pest is the old one of grubbing out the affected plants as soon as they are noticed. It would be well, also, to discard those varieties known to be subject to the trouble." The varieties that rusted badly with us are the Agawam, Ancient Briton, Taylor's Prolific, Tyler, Erie and Kittatinny. More is said of this disease under 'Notes on Blackberries.' If spraying with the Bordeaux mixture about four times a season, twice before the fruit ripens and twice after it is picked, is combined with the grubbing out process, the disease doubtless can be gradually eradicated from a field. This will require the utmost vigilance and persistency of effort.

Quince Leaf Blight, Cause of Unfruitfulness:—During the spring and early summer our Quince trees were so badly affected with the leaf blight (*Entomosporium maculatum*) that most of the trees lost nearly all of their leaves before August. It was determined at that late day to spray them with the medium strength Bordeaux mixture, to see if the disease could not be checked and the trees induced to throw out a new set of leaves. The trees began a new growth and sent out new foliage soon after the first spraying. A second application was given three weeks later, and from that time till the frosts in October the new foliage remained healthy.

Col. A. W. Pearson, of Vineland, N. J., stated† that the Quince tree he sprayed in 1888 with the Bordeaux mixture was the only one of his orchard that fruited in 1889. I am often asked why it is that the Quince trees in Maryland fruit only once in six or eight years

*Journal Mycology, No. 3, Vol. VI., p. 106.

†Bull. 11, Sec. Veg. Pathol., U. S. Dept. Agr., p. 47.

and then bear only ill-formed fruit. The answer to this, no doubt, lies in the fact that the Quince in this humid climate is subject to heavy attacks of this and another leaf blight, that defoliates the trees prematurely and thus prevents them from storing up enough energy to support a crop or even to form fruit buds. The constitution of the trees is weakened by the yearly attacks. I have found this disease in nearly every part of the State, and feel confident that if these trees could be sprayed a few times every season—twice in early spring with the Bordeaux mixture, and followed in the summer, while the fruit may be present, with two or three applications of the Copper Carbonate and Carbonate of Ammonia mixture, there would be good crops of Quinces every year. Occasionally we may have a season in which the conditions of heat and moisture are not conducive to the growth of these fungi, and the result is that the following year, or even the same year, we may have a crop of fruit.

III.—Spraying Apparatus.

The spraying machine or outfit has become as important to the modern grower of trees and plants as any of the improved implements for tilling the soil. While spraying has become a very important operation upon the farm, there are but few that appreciate or understand its utility and economy. It therefore becomes our duty to place before those who have little or no knowledge of spraying and spraying apparatus, such information as will at least guide them properly in acquiring facts concerning the usefulness of the work, and in the selection of the best and most efficient implements. On the preceding pages the useful effects of spraying has been shown and the methods of making the mixtures described. It remains to be shown where apparatus can be obtained, and what points should be observed in purchasing outfits.

Spraying apparatus for combating fungi and insects has been greatly improved within the last few years, till now there are many outfits that deserve the attention of the fruit grower. It was not possible for us to test and report upon all the machines in the market. We could only select a few, and while we tried to get good ones, and of a variety suited to the work of our tests, it must be understood that there are other outfits on the market just as good and possibly better. Every outfit we have yet tried or seen has both merits and faults. None are perfect, nor is any one of them fitted for

all phases and kinds of spraying. Hence, it is best to send for the different advertising catalogues, and by a comparative study one can be selected, or in some cases parts of one and parts of another, to suit the peculiar line of work to be done. The addresses of some of the manufacturers are as follows: Nixon Nozzle and Machine Co., Dayton, O.; Field Force Pump Co., Lockport, N. Y.; Goulds Manufacturing Co., Seneca Falls, N. Y.; Rumsey & Co., Seneca Falls, N. Y.; Lansing Iron Works, Lansing, Mich.; Superior Machine Co., Springfield, O.; Leitch & Sons, No. 1214 D street, Washington, D. C.; Adam Weaber, Vineland. N. J.; Albinson & Co., No. 2026 14th street, Washington, D. C.; Wm. Stahl, Quincy, Ill.; P. C. Lewis, Catskill, N. Y.; Thos. Woodason, 451 E. Cambria street, Philadelphia, Pa.

The essentials of an outfit for most growers are (1) durability, (2) cheapness, (3) simple construction and handling, (4) rapidity of action, (5) efficiency, and (6) uniform size of fittings.

As to *Durability*, the cylinder, piston and piston rod, and all parts of a pump that come in contact with the liquid to be sprayed should be made of copper or brass. Iron is too easily acted upon by the mixtures used as fungicides, and everyone should pay a little extra and get a pump with brass parts and fittings. It is the more economical in the end. Cheap outfits are often made with iron parts, and while they may last a season, they will soon corrode and become worthless.

Cheapness is an important consideration, but it should not be allowed to overshadow all others. Our experience and observation teach us that there are several factors that enter into true economy in this connection. As said above, brass fittings and parts are the cheapest in the end. An outfit that does the work most rapidly, and at the same time is efficient and saving in materials, is cheaper than one costing less but which does the work far more slowly. This is the actual difference between some outfits. For all orchards or fields requiring fifty or more gallons of material for each spraying, it is far better for the grower who can buy but one machine to get one that uses a barrel for the reservoir of the spraying mixture instead of a four or five gallon knapsack sprayer. Such a machine as the Climax Tripod Pump, No. 3, made by the Nixon Nozzle Machine Co., of Dayton, O., or the Perfection Spraying outfit, made by the Field Force Pump Co., of Lockport, N. Y., with Vermorel nozzles,

will be found to be the cheapest and best all-purpose outfit. Illustrations of these, and other spraying implements, appear a few pages later. Either of these pumps can be mounted on a barrel, on a common wagon or cart, or for low work on a sled, and drawn by a team or single horse, and will do three or four times as much work in a day as a knapsack sprayer, and with much less effort on the part of the operator. Such outfits cost no more than the knapsack sprayers and are far easier to handle, and do more rapid work. For small gardens and orchards of a few trees, for shrubbery, vines, etc., a knapsack is very convenient, and will do the work thoroughly and quite rapidly, if not required to throw the spray too high. But it requires too much time to refill, and the flow is too slow for work on a large scale, and high objects cannot be reached. Cheapness depends somewhat upon the nozzle that is used. Some nozzles waste the material and are not as efficacious as others. A nozzle that reduces the spraying liquid to a fine mist without allowing drops to fall to the ground is the ideal. Beyond question, the Vermorel or cyclone nozzle, now manufactured by several of the firms mentioned, and shown later, is the best of all. It should be made with a needle-pointed, packed degorger, such that will clear the aperture of any clogging material, and not allow the escape of any of the liquid toward the operator, or in fact, in any direction except as spray. The *Modified Vermorel* nozzle, as designed by Prof. B. T. Galloway, and described and illustrated in the Journal of Mycology, Vol. 5, No. II., and shown on a later page, is one of the best forms of this nozzle yet made. It can be obtained from either of the Washington firms named above. I have used other nozzles, but they are all liable to clog, and require too much time to keep them free from particles that are sure to float in any spraying mixture. Besides this clogging they are more wasteful of the spraying liquid, and do not throw it in as fine a spray as the Vermorel. The Nixon nozzles are the second best we have used. They form a fine spray but are easily clogged, and do not spread out the spraying stream as much as the Vermorel nozzle.

A convenient and commendable feature of the Nixon Climax Tripod Pump is the *tripod* which makes the pump detachable from the barrel containing the spraying mixture. Most pumps fastened to the barrel, require a large opening in the head to receive the cylinder of the pump, and the parts below the cylinder are usually *iron*,

which is objectionable for most of the spraying liquids used. The suction hose of the Nixon pump should be eight or ten feet long, instead of four, so as to be able to introduce the hose into the head of a barrel that stands on end. Barrels are cheap reservoirs, but I have found, after several trials, that they should be used "on end," and not lying on their sides. In large orchards, it saves time to place five barrels in a wagon, (or more, if the wagon is larger) and with the tripod pump change from barrel to barrel as they become empty, by simply taking the suction hose from the empty one and dropping it through a two-inch hole into a full one. A pump with two discharge orifices is the best. For all liquids that need constant stirring one of the discharge hose can be introduced into the barrel containing the spraying mixture, and a forcible return stream will, with the same strokes of the pump handle, agitate the liquid better than either an automatic agitator or one requiring extra hand work. For liquids not requiring constant stirring, both discharge hose can be manipulated by one operator and the work be accomplished in half the time. These discharge hose should each be sixteen feet long and one-half inch in diameter. The one-fourth inch hose recommended by some is too small and slow in its action. It is very desirable that all manufacturers should agree upon fittings of the same size, so that parts of the many machines now made can be used with any one of them. Nozzles, especially, should all be made with screws of the same size. A spraying outfit such as described, with the additions mentioned, should not cost more than fourteen dollars. There are cheaper outfits in first cost, but they cost more "in the long run."

There are several knapsack sprayers, but it is useless to describe the individual merits of each. I have used the "Eureka" and the "Japy," and find them both satisfactory. The "Galloway Knapsack" is a cheaper machine, and from good evidence, I believe it an improvement over other knapsack sprayers. The "Garfield" we have not tested, but from its description, it seems to have points of considerable merit and is quite reasonable in price.

Descriptions of Some Good Spraying Appliances.

FIG. 1.

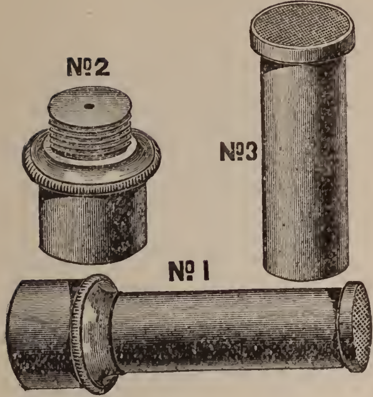


FIG. 1.—*The Climax Nozzle*, made by the Nixon Nozzle Machine Co., Dayton, Ohio. No. 3 shows the outer end covered by a wire screen which cuts the water into a fine spray. No. 2 shows nipple end of the nozzle upon which No. 3 screws on. No. 1 shows the nozzle entire. These nozzles are fitted with either ½ or ¾-inch thread, and will fit corresponding sizes of gas pipe or hose. They are made of six sizes, which produce sprays of any desired fineness. Price, one dollar each.

FIG. 2.

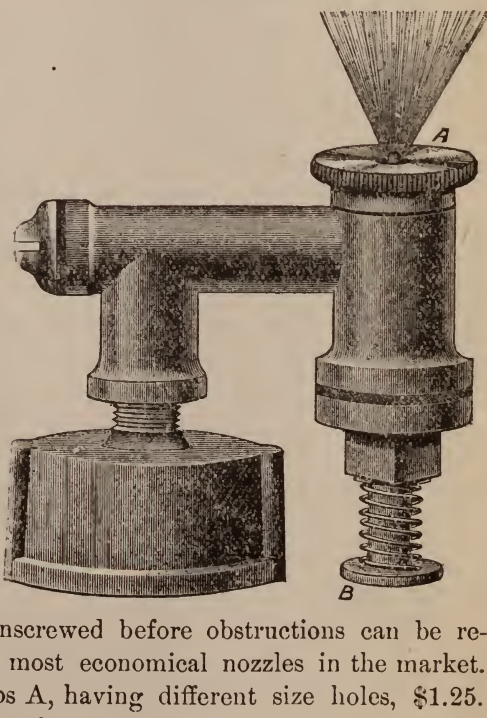


FIG. 2.—*Combination Vermorel Nozzle.*—This cut shows this nozzle full size, made by Field Force Pump Co. It throws a fine spray that leaves the aperture in a twisted or spiral whorl. The spray can be thrown about 15 feet. The cap A can be removed and a solid stream be thrown 40 feet. When the nozzle becomes clogged, it is cleared by simply pressing upon the broadhead B. This is easily and quickly done and does not cause delay, as with those nozzles which require parts to be unscrewed before obstructions can be removed. This is one of the most economical nozzles in the market. Price, ¾-inch with two caps A, having different size holes, $1.25. Sent by mail, postage paid, at above price.

FIG. 3.

FIG. 3.—*Improved Vermorel Nozzle.*—This makes one of the best nozzles on the market. The degorger is easily operated by the thumb lever and is kept in place by a spring. This is the best nozzle for knapsack sprayers, but is no better than the one shown in fig. 2 for sprayers with which long poles are used to reach the tops of trees, as the long handle part is not needed.

FIG. 4.

FIG. 4.—*Climax Tipod Pump.*—New style made by Nixon Nozzle & Machine Co. This pump is one of the best made for a variety of uses. It can be used in connection with a barrel, either by placing the suction hose, if eight feet long, through an opening in the head of a barrel, or by taking off the legs and fastening the pump directly to the head of a barrel with large screws sent with each pump. The screws should be a little longer to hold the pump securely. I would recommend, when ordering, to have the suction hose made eight feet long, and 16 feet of $\frac{1}{2}$-inch discharge pipe. The $\frac{1}{4}$-inch discharge pipe should be discarded by all manufacturers, as it is entirely too slow. No. 3 size is furnished with two discharge hose, cut shows but one, but both No. 2 and 3 have two discharge orifices. These pumps are made with brass fittings, and all parts that come in contact with the spraying mixtures are brass. Price No. 2, $15.00. Price No. 3, $20.00.

FIG. 5.

FIG. 5.—*Climax Pump*, mounted upon a barrel with a new automatic agitator attached to the handle. With every stroke of the handle the liquid is stirred within the barrel. This is one of the latest improvements, and while we have not tried it, believe it a saving of time to the operator and a thorough and constant agitation of the liquid not attained by the old agitators with the same pump. It also allows the use of both discharge hose for spraying, instead of using one to agitate the liquid as recommended above, or as shown in Perfection outfit in fig. 6.

FIG. 6.

FIG. 6.—"*Perfection*" *Spraying Outfit*, made by Field Force Pump Co. It supplies an automatic agitation of the liquid by the introduction of one of the discharge pipes back into the barrel, leaving but one to throw the liquid on the trees. This is one of the cheapest and best outfits in the market. We would not recommend the use of the *graduated* nozzle as shown in the cut. The Vermorel, as shown in fig. 2, could easily replace it and be far more economical, both of liquid and time. Instead of an iron *suction* pipe, I would use one of rubber. The iron will corrode in most spraying liquids. With these two changes and a sixteen foot ½-inch (inside measurement) discharge hose, there cannot be a much cheaper and better outfit. With brass cylinder, plunger and rod, price is $12.00. A tight cap is furnished to close up opening *B* when desired. Weight, 55 pounds. Never buy the outfit with *iron* fittings for spraying purposes.

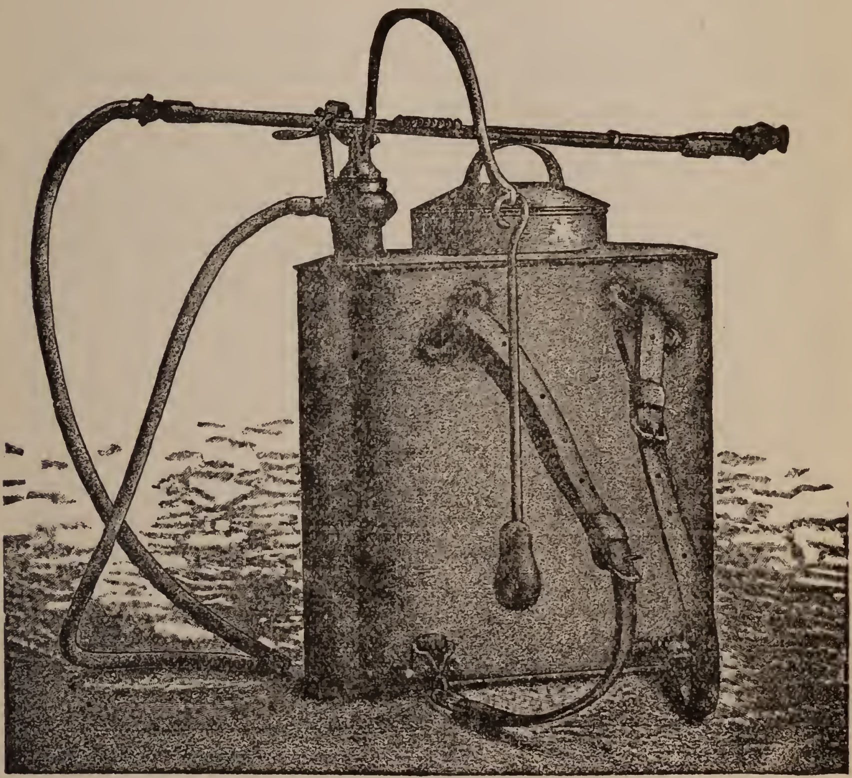
FIG. 7.—"*Little Gem*" *Spraying Pump*, made by Field Force Pump Co. This pump is made entirely of brass. It has an air chamber which enables it to throw a steady stream for thirty seconds after the operator stops pumping. This pump is neat, strong and not likely to get out of repair. It weighs but 4 pounds. Can be used

FIG. 7.

with any pail to hold the liquid, and for the small garden or vineyard it is one of the best outfits we can recommend. It is supplied with the Vermorel nozzle and about four feet of discharge hose for $4.50. Additional hose at 15 cents per foot can be bought. One length of sixteen feet would enable a person to spray a few trees quite easily and cheaply.

Fig. 8.—*Galloway Knapsack Sprayer.*—This sprayer was designed by Prof. B. T. Galloway, chief of the Division of Vegetable Pathology, and is not patented. It is made of the best of materials by Leitch & Sons, 1214 D street, Washington, D. C., for about $12.00. It has more

Fig. 8.



reservoir room than most such sprayers, for the air chamber is in the hollow piston, thus making a separate air chamber as found in most pumps unnecessary. This is one of the cheapest and best sprayers on the market. Largest size holds six gallons. It is supplied with the improved Vermorel nozzle shown in fig. 3.

IV.—Tomato Variety Test.

The variety test of 1890, as recorded in Bulletin No. 11, of this Station, was repeated the past season to give the grower a wider range of comparative data. This trial included plants from 108 different lots of seed, bearing 84 distinct names. Some of the varieties were duplicated by obtaining seed from different seedsmen for comparison. Ignotum seed was obtained from six different sources.

The seed was all planted in a hotbed, March 10th, 1891. The plants were well cultivated in the bed, but were not transplanted to a cold-frame, as is often done. On May 12th, after a medium rain the night before, the plants were all transplanted to the field. Ten plants were set in each plat or row, of thirty-five feet in length, with the rows four feet apart. The soil for the test was very uniform in character and level. It was a chocolate colored loam, and was not known to have ever had a crop of tomatoes on it before. No crop grew upon it the previous year except some small orchard trees. The rows were opened with a turning-plow, and in the furrow the following mixture of fertilizers was applied:—Dried Ground Fish, 191 ℔s; Nitrate Soda, 42 ℔s; Dissolved S. C. Rock, 162 ℔s; Muriate Potash, 61 ℔s.

This was the amount applied to the 126 plats, planted to tomatoes, making nearly three pounds ten ounces of the mixture to each plat, or at the rate of 1100 pounds per acre. The mixture gave plant food in these proportions:—5 per cent. of nitrogen; 10 per cent. phosphoric acid, and 8 per cent. potash. Each row was harrowed, which mixed the fertilizers with the soil and more than half filled the furrow. The plants were set in the half filled furrows at once.

Most of the foliage was removed to prevent severe wilting. Very few plants were lost. Cutworms killed a few, and these were replanted at once and the worms dug out and destroyed. The soil was kept free from weeds and well stirred. The plants grew finely, as the season was favorable. They were not trimmed or trained, but allowed full freedom of growth.

The fruit began to ripen the 20th of July, and continued till October 24th, when, after twenty-one pickings, frost prevented farther growth.

Nearly every plat remained complete during the season, and if a fungus disease (Cladosporium fulvum) had not attacked the plants, the results would have been nearly perfect. This disease began in a small way about the time the first fruits ripened and gradually increased in its severity till late in September, when many of the plants were entirely bare of leaves. It attacked some varieties more severely than others and greatly decreased the total production in numerous cases. The records show what varieties yield best under such circumstances and are least susceptible to this severe disease.

Many notes were taken during the season, but only such records as are thought to be of special interest are here given. Table II., which occupies the next four pages, gives all the comparative data necessary. From this Table some deductions can be made:—

The varieties which appeared to us to rank highest upon the combined basis of quality, smoothness and value, for market and canning, are the Ignotum, Brandywine, Favorite, Paragon, Volunteer and Fulton Market. The record of the two previous years places Ignotum at the head of the list for quality (as well as quantity), with Livingston's Favorite following closely. This season, in respect to quantity, the six lots of Ignotum from seed obtained from different sources, varied in yield from 10.72 to 16.01 tons per acre. Of the new varieties tested, Livingston's Stone proved to be the best. It is a fine, smooth, slightly flattened tomato, bright red in color, of medium size, with an average weight of about five ounces. Of those examined in cross-section, all contained eight cells and thick walls. We believe this variety will take high rank.

Largest Producers:–The ten varieties named on page 406 were found to give the largest crops of fruit of all those tested. By comparing this list with the one on page 52 of Bulletin No. 11 of this Station, it will be seen that the Table Queen is the only name on both. And our 1891 list of "the best ten," has but one name which was on our list for 1889, that being the Fulton Market. The varieties that take the lead in product thus vary from year to year, and no one can say, from last season's experience, what tomato will prove most productive next season. It should be stated, however, that we did not grow this last year, the varieties which did the best in yield, the year before, from seed from the same sources, as in that trial; this may partly account for the different results.

TABLE II.—TOMATO VARIETY TEST FOR THE SEASON OF 1891.—*Comparative Record of Product, etc.*

Plat Number.	Varieties.	Seedsmen.	Date of First Picking.	Early Period. July 20-Aug. 10.		Medium Period Aug. 10-Sep 1.		Late Period. Sep. 1-Oct 24.		Total Number Ripe Fruits.	Total Weight Ripe Fruits.	Yield Per Acre in Tons.	Color of Fruit.
				Number Fruits.	Lbs. oz.	Number Fruits.	Lbs. oz.	Number Fruits.	Lbs. oz		Lbs. oz.		
308	Acme	Land	July 24	40	15— 5	161	62—12	124	15—12	325	93—13	14.61	Purple.
309	Annie Dine	Wilson	" 24	29	16— 6	142	74— 2	86	21— 1	257	111— 9	17.43	Purplish
310	Atlantic Prize	Stor. & H.	" 24	75	20— 8	210	54—12	9	2— 8	294	77—12	12.13	Red.
311	" "	D. M. F. & Co.	" 24	88	26—11	153	40— 3	18	3—11	259	78—15	12.28	"
312	" "	Tilling	" 24	82	24—13	216	64—15	17	2—	315	91—12	14.30	"
313	" "	Io. S. Co.	" 24	89	22—12	189	40—	7	—12	285	63— 8	9.79	"
314	Beauty	Land	" 20	62	14—	147	62—10	115	24—14	324	101— 8	15.70	"
315	Belle	Ford	" 24	9	2—13	175	67— 7	74	13— 5	258	83— 9	13.06	"
316	Bermuda Ex. Ea.	Land	" 24	70	25—	186	54— 3	9	1—12	265	80—15	12.09	Purple.
317	Brandywine	Ford	" 24	20	8—15	324	108— 6	75	17—13	419	135— 1	20.99	Red.
318	Bronzed Leaved	Greg	" 28	5	2— 4	194	82—11	22	7— 8	221	92— 7	14.30	"
319	Burpee's Climax	Burpee	" 20	41	17— 8	246	82— 6	54	9—14	341	109—12	17.10	Purplish
320	Buist's Beauty	Buist	" 24	20	8— 2	206	82—11	68	12—15	294	103—12	16.17	Red.
321	California Fig	Salzer	" 24	200	6—12	1847	40— 5	840	20—13	2887	69—14	10.88	Yellow.
322	Cardinal	Land	" 24	27	8—15	171	52—10	116	17— 1	314	78—10	12.28	Red.
323	Cincinnati Purple	McCull	Aug. 1	2	—14	106	44— 8	81	20— 4	189	65—10	9.95	Purple.
324	Climax	Cowan	July 24	56	15— 7	223	73— 3	43	7— 1	322	95—15	14.52	"
325	Dw'f Champion	Land	" 20	69	21— 3	219	60—	13	1—14	301	83— 1	12 90	"
326	" "	McCull	" 20	48	12— 3	160	42— 7	35	5— 8	243	60— 2	9.33	"
327	" "	Io. S. Co.	" 20	35	9—14	134	41— 1	15	2— 9	184	53— 7	8.24	"
328	Ea. Jersey	Land	Aug. 1	100	29— 9	190	55—13	59	7— 1	349	92— 7	14.30	Red.
329	Ea. Richmond	"	" 1	63	23— 5	195	52—15	61	13— 1	219	89— 5	13.83	Lightred
330	Ea. M'kt Champion	Johnson & Stks	July 20	59	15— 8	252	62—	26	5— 6	337	82—14	12.40	Purple.
331	Ea. Smoot Red	Buist	" 28	40	13—15	195	70—15	38	8— 3	273	93— 1	14.46	Red.
332	Ea. Washington	Cowan	" 28	121	28— 1	251	57—13	14	1— 5	386	87— 3	13.52	"

333	Ex. Ea. Advance....	Bragg.........	July	24....	227	41— 1	326	66—14	13	2— 1	566	110—	17.10	Red.
334	Ex. Early..........	Horner........	"	24....	133	34— 8	166	44—	13	1— 4	312	79—12	12.44	"
335	Ex. Ea. Jersey......	Land..........	"	20....	131	38— 3	205	61— 8	63	5—14	399	105— 9	16.32	"
336	Emery..............	Rawson.......	"	24....	75	16—11	387	79— 1	73	8— 7	435	94— 3	14.61	"
337	Ely's King of Earlies.	Ely....... ...	"	24....	222	36—15	253	47— 3	12	1— 6	487	85— 8	13.21	"
338	Essex Hybrid........	D. M. F. & Co	"	20....	105	30— 6	216	62— 9	18	2— 2	339	95— 1	14.77	"
339	Faultless............	Greg..........	"	24....	172	34— 5	393	24—11	2	— 5	567	59— 5	9.17	Deep red
340	Favorite...	Land..	"	28....	62	19—12	264	73—12	32	13— 1	358	106— 9	16.48	Red.
341	Fejee Imp...........	"	"	24....	46	18— 2	180	57—13	44	7— 7	270	83— 6	12.90	Purple.
342	Fire King...........	Buckbee......	Aug.	1....	77	17— 2	248	54—14	61	7— 5	386	79— 5	12.28	Red.
343	Ford's Alpha........	Ford & Son....	July	28....	156	35— 4	162	38—	49	3— 8	367	76—12	11.97	"
344	Fulton Market......	U. S. Dept.....	"	20....	50	16—10	259	104—13	57	8— 7	366	127—14	19.90	"
345	Gen'l McClellan....	Cowen........	Aug.	1....	13	5—	150	71—17	10	3— 8	173	80— 9	12.44	Purple.
346	Golden Queen........	Thor..........	July	20....	48	13—	262	69— 5	17	3— 7	327	85—12	13.37	Yellow.
347	" Rod.........	Hend.........	"	20....	41	11— 6	228	72— 3	48	7— 2	317	90—11	14.15	"
348	" Sunrise......	"	"	20....	38	12— 1	274	108— 7	30	4— 5	342	124—13	19.43	"
349	" Trophy......	Cleve..........	Aug.	1....	96	21—11	271	64— 7	32	2—12	399	88—14	13.83	"
350	" "	Land..........	"	1....	40	12— 5	219	75— 3	65	11— 3	324	98—11	15.39	"
351	Hathaway's Excel...	"	July	24....	52	11—15	256	68—12	85	8—15	393	89—10	13.99	Red.
352	Haines' No. 64.......	N. B. & G.....	"	20....	49	13—10	316	101— 7	80	12— 9	445	127—10	19.90	"
353	Horsford's Prelude...	Thor.........	"	20....	346	39— 4	364	42— 7	37	2—10	747	84— 5	13.06	"
354	" " ...	Dreer...... ..	"	20....	221	27—11	561	59—14	155	6—15	937	94— 8	14.61	"
355	Hovey...............	Thor..........	"	24....	38	10— 5	221	59— 1	69	9— 2	328	78— 8	12.12	Purple.
356	Hubbard's Curl'd Leaf	Currie Bros....	Aug.	3....	106	20—14	257	54—13	31	3— 3	394	78—14	12.28	Lightred
357	Hundred Days........	Thor..........	July	20....	179	33— 4	522	75—10	29	2—13	730	111—11	17.41	Red.
358	Ignotum.............	Dreer.........	"	20....	23	9—13	146	63— 9	40	9—12	209	83— 2	12.90	"
359	"	Io. S. Co......	"	28....	30	9— 7	155	53— 8	27	5—12	212	68—11	10.72	"
360	"	Plants. S. Co..	"	20....	44	16— 8	134	59— 8	51	5—10	239	81—10	12.75	"
361	"	Wilson........	"	20....	42	18— 1	175	74— 3	45	11— 4	262	103— 8	16.01	"
362	"	Thor..........	Aug.	5.. .	27	10—12	131	52—14	28	6— 5	186	69—15	10.88	"
363	Imp. Queen.........	"	July	20....	41	13— 9	166	53—15	59	6— 5	266	73—13	11.50	"
364	La Crosse...........	Salzer.........	"	24....	45	13—12	224	53— 4	22	16— 8	291	83— 8	12.90	Purple.
365	Large Yellow........	Thor..........	"	28....	89	16— 8	356	69—	54	11—11	499	97— 3	15.08	Yellow.
366	Little Gem..........	Rawson.......	"	20....	201	15— 5	932	75— 2	42	7— 4	1175	97—11	15.23	Red.
367	Livingston's Stone...	Dreer.........	"	24....	21	9— 9	198	74— 5	43	10—14	262	94—12	14.77	"
368	" " ...	Liv...........	Aug.	1....	12	5—12	198	95—14	42	11— 7	252	112 1	17.41	"
369	Mansfield's Tree	Wilson	"	1....	11	5—11	112	46—12	38	6— 8	161	58—15	9.17	"
370	Marquis.............	Buckbee......	"	5....	36	7— 2	305	50—	10	1—	451	58— 2	9.01	"

TABLE II.—*Concluded.*

Plat Number.	Varieties.	Seedsmen.	Date of First Picking.	Early Period. July 20. Aug. 10. Number Fruits.	Early Period. Lbs. oz.	Medium Period Aug. 10–Sep. 1. Number Fruits.	Medium Period Lbs. oz.	Late Period. Sep. 1–Oct 24. Number Fruits.	Late Period. Lbs. oz	Total Number Ripe Fruits.	Total Weight Ripe Fruits. Lbs. oz.	Yield Per Acre in Tons.	Color of Fruit.
371	Mayflower	Currie Bros	July 28	74	19—13	270	93—	86	21—10	440	134— 7	20.83	Red.
372	Matchless	Burpee	Aug. 1	7	3— 9	180	78—13	80	20—12	267	103— 2	16.01	"
373	McCullom's Hybrid	Dreer	" 1	21	7—15	210	79—13	66	17— 2	297	104—14	16.32	"
374	Mikado	Thor	" 3	8	3— 9	120	55—10	28	10— 7	156	69—10	10.88	Purple.
375	Morning Star	Salzer	July 20	47	16— 5	177	72— 3	64	10— 7	288	98—15	15.39	Red.
376	New Bay State	Bragg	Aug. 1	18	5—10	179	66— 7	52	12—15	249	85— 2	13.21	"
377	New Jersey	Thor	July 24	21	7— 1	116	38— 4	41	8—10	178	53—15	8.39	"
378	New Peach	Io. S. Co	Aug. 5	16	1—12	354	36— 3	439	32—10	809	70— 9	10.88	Purplish
379	New Yel. Peach	Stor & H	" 5	20	2—11	316	37—10	258	20— 1	594	60— 6	9.33	Yellow.
380	New Zeland Fig	Wilson	July 24	203	10—13	848	38— 7	216	4— 8	1267	53—12	8.39	"
381	Optimus	D. M. F. & Co.	" 20	63	17—	183	46—10	21	2—13	267	66— 7	10.26	Red.
382	"	Thor	" 24	37	10—15	199	57— 8	44	5—12	280	74— 3	11.50	"
383	Paragon	Land	" 20	23	7— 1	168	56— 8	37	5—	228	68— 9	10.57	"
384	"	Farqu	" 20	51	16—10	223	75—15	66	13— 7	340	106— 2	16.48	Deep red
385	Peach	"	" 24	84	8—15	545	62— 5	335	29— 2	964	100— 6	15.55	Purplish
386	Perfect Gem	Salzer	" 20	70	20— 9	184	56—13	34	4—13	288	82— 3	12.75	Deep red
387	Potato Leaf	Liv	" 24	18	18— 8	136	45—	21	3—14	175	67— 6	10.41	Purple.
388	Prize Belle	Buist	" 24	25	8—11	152	66—10	87	16— 9	264	91—14	14.30	Dark red
389	Pres'dt Cleveland	Farqu	" 24	61	16— 1	160	58—13	46	8—15	267	83—13	13.06	"
390	Puritan	Thor	Aug. 1	46	15—12	171	68— 8	65	11— 5	282	95— 9	14.77	Red.
391	"	Rawson	July 24	65	21—12	261	77— 5	73	13— 1	399	112— 2	17.41	"
392	Red Apple	D. M. F. & Co.	" 20	48	13—13	211	64—11	58	7—15	317	86— 7	13.37	"
393	Red Cross	Farqu	" 24	61	16—10	183	50—15	57	10— 2	301	77—11	12.12	"
394	Salzer's Telegraph	Salzer	" 28	164	40—10	74	31—13	6	—15	244	73— 6	11.35	"
395	Salzer's Ea. of All	"	" 28	89	17—11	344	75— 5	29	2—15	462	95—15	14.92	Dark red

396	Scoville's Hybrid....	Burpee........	July	24....	41	13— 6	178	60— 9	42	14— 3	261	88— 2	13.68	Dark red
397	Shah..............	Hend.........	Aug.	3....	24	14— 4	143	65—15	55	13— 2	222	93— 5	14.46	Yellow.
398	Table Queen	Farqu........	July	24....	43	20— 3	159	90— 2	24	9— 8	226	119—13	18.66	Purple.
399	Long Keeper........	Thor.........	"	20....	93	29— 7	317	78—	100	24—10	510	132— 1	20.52	"
400	Trophy.............	"	Aug.	3....	22	7—10	144	58—13	95	20— 9	261	87—	13.52	Red.
401	"	Land	July	24....	48	14—12	150	51— 2	40	7—11	238	73— 8	11.35	Deep red
402	"	D. M. F. & Co.	Aug.	1....	10	5— 4	125	63— 3	78	20— 4	213	88—11	13.83	"
403	Turner.............	Burpee	"	1....	8	3—11	33	16— 2	21	6— 3	62	26—	4.04	Purple.
404	Winter Ea. Essex....	Halleck.......	"	1....	15	4— 6	51	17— 9	46	10— 2	112	32— 1	4.97	Red.
405	Wonder of Italy.....	Pearce	July	28....	70	5—10	929	39— 1	511	19— 4	1510	63—15	9.95	"
406	Volunteer..	Stor. & H......	"	28....	38	11—14	231	77— 3	63	11— 3	332	100— 4	15.55	Dark red
407	Dw'f Champion......	Jos. Harris....	"	28....	18	4—15	104	28— 6	14	1—12	136	35— 1	5.44	Purple.
408	Potomas............	"	Aug.	12....	......	....	23	11—14	22	6—15	45	18—13	2.95	"
409	Favorite...........	Liv......	July	24....	35	11— 6	147	53—	55	12— 2	237	76— 8	11.81	Red.
410	Horsford's Prelude...	Rawson.......	"	20....	203	30—	863	70— 1	42	4—11	1108	104—12	16.32	Dark red
411	Ignotum............	"	"	20....	39	15— 4	146	61— 1	37	11— 6	222	87—11	13.68	"
412	Beauty.............	Liv..........	"	24....	17	5— 2	81	36— 5	55	9— 6	153	50—13	7.93	Purple.
413	Perfection..........	"	"	28....	48	14— 4	155	59—13	57	11— 8	260	85— 9	13.21	Red.
414	New Yel. Peach......	Rawson.......	"	28....	2	— 6	71	10— 9	70	7— 8	143	18— 7	2 79	Yellow.
416	Paragon............	Liv...........	Aug.	3....	26	8— 4	109	38— 1	22	4— 1	157	50— 6	7.77	Red.

TEN LARGEST PRODUCERS,—1891.

No.	Tons.	Variety.	Seed from—
317	20.99	Brandywine................	Ford.
371	20.83	May Flower................	Currie.
399	20.52	Long Keeper................	Thorburn.
344	19.90	Fulton Market..............	Department Agriculture.
348	19.43	Golden Sunrise..............	Henderson.
398	18.66	Table Queen................	Farquhar.
309	17.43	Annie Dine.................	Wilson.
368	17.41	Livingston's Stone...........	Livingston.
391	17.41	Puritan....................	Rawson.
357	17.41	Hundred Days	Thorburn.

The average yield of these ten varieties was at the rate of 19 tons or 633 bushels per acre. This is rather more than obtained the year before. The product of the Brandywine, at the rate of 21 tons or 700 bushels of tomatoes per acre, is certainly creditable, for field culture.

The whole list produced larger crops in 1891 than in 1890; in the latter year there were but twenty varieties which gave over 15 tons per acre, while this past season there were twenty-eight. The varieties not named above, which produced at the rate of 17 to 15 tons per acre in 1891, are these:—Bronze Leaf, Burpee's Climax, Extra Early Advance, Favorite, Paragon, Extra Early Jersey, McCullom's Hybrid, Horsford's Prelude, Buist's Beauty, Ignotum, Matchless, Beauty, Peach, Volunteer, Morning Star, Golden Trophy, Little Gem and Large Yellow. Among these names are found several which appeared in our "best ten" lists of previous years. It is noteworthy that several of the yellow varieties and the Peach were among the largest producers the past season.

Earliest Producers:—As already stated, the first picking of ripe tomatoes was on July 20th. The three weeks from this date to August 10th is considered as the period of early fruiting. The following is a list of those varieties which gave a good yield during this

period. The record is from ten (10) plants of each variety, giving the number of fruits and their weight, picked before the tenth of August; also, the rate of total product per acre of the same varieties for the entire season, and the source of our seed:

Varieties.	Number fruits.	Weight lbs. ozs.	Rate per acre, tons.	Seedsman.
Extra Early Advance..........	227	41— 1	17.10	Bragg.
Salzer's Telegraph.	164	40—10	11.35	Salzer.
Horsford's Prelude	346	39— 4	13.06	Thorburn.
Extra Early Jersey............	131	38— 3	16.32	Landreth.
Ely's King of Earlies..........	222	36—15	13.21	Ely.
Ford's Alpha.	156	35— 4	11.97	Ford.
Extra Early............... ...	133	34— 8	12.44	Horner.
Faultless.....................	172	34— 5	9.17	Gregory.
Hundred Days	179	33— 4	17.41	Thorburn.
Essex Hybrid................	105	30— 6	14.77	Ferry.
Early Jersey..................	100	29— 9	14.30	Land.
Long Keeper.....	93	29— 7	20.52	Thorburn.
Early Washington.............	121	28— 1	13.52	Cowan.
Atlantic Prize.................	88	26—11	12.28	Ferry.
Bermuda, Extra Early.........	70	25— 0	12 09	Land.

It will be noticed from this list that the varieties giving the largest of these early yields are Extra Early Advance, Extra Early Jersey and Hundred Days. Extra Early Jersey gave the largest sized fruit with a good yield. The Hundred Days is rather too small to be as valuable as the Advance and the Jersey. These last two are only medium in size with fruits usually smooth and regular.

V.—*Comparison of Potted with Transplanted Tomato Plants.*

During the season of 1890, eighty-three sets of pot-grown plants were compared with eighty-three sets transplanted in the ordinary way. The results were strikingly in favor of the pot-grown plants.

This season it was thought best to repeat this test on a basis large enough to be confirmatory of last season's work. Accordingly, fifteen sets of plants were started at the same time in both pots or cans and the hotbed soil. The seeds were placed in common two-pound fruit cans which had both ends melted off and were placed close together in rows in a hotbed. These were rapidly filled with a good compost by shoveling it over the whole crown of cans. When the plants were large enough, they were thinned to one to each can. The plants raised in the open soil of the hotbed were not transplanted to a cold frame Both lots were set in the field on May 12th, immediately after a shower. The potted plants never wilted, nor showed any signs of checked growth. The transplanted plants did not start to grow for several days. The rows holding the two lots of plants were side by side and received the same treatment. None of the potted plants were lost by transplanting, while a few of those transplanted were killed by wilting or by cutworms; these were at once replaced and the plots kept complete. The results are fully given in Table III.

Contradictions may appear in the first columns of picking records, because in nine cases the very first fruits ripened on the transplanted plants; but taking the results of the early bearing period of three weeks, the potted plants are found to have produced more than those transplanted in all cases but one. The comparisons must, of course, be made on the weight of product, although the record of number of fruits is interesting, because, taken with the weights, it shows the relative size of the tomatoes. As to yield for the entire fruiting season, the potted sets gave more than the transplanted in all but three cases. The bottom line of the Table, giving the averages, is the most instructive part of the record, and needs no comment.

This record, as well as that of the year before, shows that potted plants mature more fruit than those transplanted, and also that a large part of it is produced earlier in the season. The profit of this method of treating tomato plants cannot, therefore, be doubted, so far as market gardening or limited culture is concerned.

The columns of computed yields per acre show that the largest crops obtained in all our tests for the season of 1891 came from these potted plants. These cannot be fairly compared with the preceding records of the general variety tests, because the conditions were not in all respects the same. But the total product of some of these sets

TABLE III.—COMPARISON OF POTTED AND TRANSPLANTED TOMATO PLANTS.

PLOT NUMBER.	VARIETIES.	SEEDSMEN.	DATE OF FIRST PICKING.		JULY 20 TO AUGUST 10. Number of fruits picked.		JULY 20 TO AUGUST 10. Weight of fruits picked.		ENTIRE FRUITING SEASON. Total Number fruits picked.		ENTIRE FRUITING SEASON. Total weight fruits picked.		RATE PER ACRE IN TONS.	
			Potted.	Transplanted.	Potted.	Transplanted.	Potted.	Transplanted.	Potted.	Transplanted.	Potted.	Transplanted.	Potted.	Transplanted.
							lbs. ozs.	lbs. ozs.			lbs. ozs.	lbs. ozs.		
308a..	Acme...............	Land.........	Aug. 1.	July 24.	41	40	14—11	15—5	235	325	61—8	93—13	9.56	14.61
310a..	Atlantic Prize.......	Stor. & H.....	July 20.	" 24.	230	75	51—2	20—8	465	294	107—6	77—12	16.70	12.13
314a..	Beauty	Land..........	" 20.	" 20.	79	62	31—3	14—0	504	324	166—0	101—8	25.74	15.70
315a..	Belle..............	Ford..	Aug. 1.	" 24.	62	9	13—13	2—13	429	258	112—13	83—9	17.53	13.06
325a..	Dwf. Champion.....	Land..........	July 24.	" 20.	86	69	22—10	21—3	408	301	104—1	83—1	16.04	12.90
328a..	Early Jersey........	Land..........	" 20.	Aug. 1.	233	100	64—13	29—9	609	349	136—13	92—7	21.38	14.30
335a..	Extra Early Jersey...	Land..........	" 24.	July 20.	164	131	51—4	38—3	368	399	103—12	105—9	16.17	16.32
337a..	Ely's King of Earlies.	Ely....	" 20.	" 24.	278	222	56—9	36—15	514	487	103—11	85—8	15.84	13.21
340a..	Favorite......	Land..........	" 20.	" 28.	57	62	23—6	19—12	257	358	114—7	106—9	17.90	16.48
344a..	Fulton Market......	U. S. Dept. Agr.	" 24.	" 20.	72	50	22—1	16—10	259	366	78—5	127—14	12.31	19.90
353a..	Horsford's Prelude...	Thor..........	" 20.	" 20.	482	346	62—11	39—4	1445	747	135—12	84—5	21.21	13 06
358a..	Ignotum	Dreer.........	Aug. 1.	" 20.	60	23	24—14	9—13	348	209	116—10	83—2	18.03	12.90
361a..	Ignotum	Wilson........	" 1.	" 20.	70	42	25—13	18—1	432	262	141—14	103—8	22.01	16.01
383a..	Paragon............	Land..........	" 7.	" 20.	54	23	17—4	7—1	384	228	128—12	68—9	19.90	10.57
402a..	Trophy.............	D. M. F. & Co.	" 5.	Aug. 1.	16	10	7—8	5—4	260	213	122—0	88—11	18.97	13.83
	Fifteen Varieties—Averages..........		July 26.	July 23.	132	84	31—5	19—9	461	341	115—9	92—7	17.95	14.33

of potted plants is well worthy of note—the Beauty (Landreth) was at the rate of 25¾ tons or 858 bushels per acre; the Ignotum (Wilson) 22 tons or 730 bushels; Early Jersey (Landreth) 21⅛ tons; Horsford's Prelude (Thorburn) 21¼ tons, and Paragon (Landreth) almost 20 tons.

If the average results obtained the past season are at all reliable, this method of growing tomato plants in pots or cans may be so managed as to be profitable when applied to field culture. The average gain is shown to have been 25 per cent., or at the rate of 3½ tons per acre. This would furnish a good margin to cover the additional outlay for labor and expense in growing the plants in pots or some cheap substitute for pots.

V.—Fertilizer Test with Tomatoes.

This is the third year this test has been made on the same plots of land, with the same fertilizers applied, and some of the same varieties of tomatoes used each year. The work was continued to confirm the results of previous years, and endeavor to determine the intensified effect of the repeated and accumulating applications of the chemical fertilizers. This last trial served also to show the folly of attempting to grow tomatoes year after year, on the same land, no matter how fertilized. The twelve plots of one-fourth of an ácre each, have been described in former Station publications. As heretofore, the plants were set four and a-half feet apart each way, giving 56 plants to each plot. This being less than on the variety test plots, the two cannot be compared. Seven varieties were used this time, each plot having 28 plants of Acme, 8 of Favorite and 4 each of Atlantic Prize, Beauty, Dwarf Champion, Ignotum and Horsford's Prelude. The Favorite plants were potted, and all the rest grown in the open soil of the hotbeds, with the stock for the variety tests. The fertilizers were applied and the plants set on the 21st of May. A full stand was maintained by replanting in the few cases necessary. The plants grew very slowly, although the Favorities (potted) did better than the rest.

As a crop, this test was a failure, as shown by the best yield, being only five tons per acre! It is therefore useless to consider the detailed record, but some deductions may be made from the general results, which are given in the following table:

TABLE IV.—YIELD OF TOMATOES ON FERTILIZER PLOTS.

Averages of Seven Varieties, on Twelve Plots, Season of 1891.

PLOT NUMBER.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
FERTILIZER APPLIED. — RATE PER ACRE.	Nitrate Soda—160 lbs.	Dried Blood—240 lbs.	Dis'd Bone Black—320 lbs.	Nothing.	Muriate Potash—160 lbs.	Nitrate Soda—160 lbs. Dis'd Bone Black—320 lbs.	Dis'd Bone Black—640 lbs.	Nitrate Soda—160 lbs. Muriate Potash—160 lbs.	Nothing.	Nitrate Soda—160 lbs. Muriate Potash—320 lbs.	Dis'd Bone Black—320 lbs. Muriate Potash—160 lbs.	Nitrate Soda—160 lbs. Muriate Potash—160 lbs. Dis'd Bone Black—320 lbs.
Number of Tomatoes picked per plot	1028	376	330	259	565	621	818	629	366	518	1002	973
Product per plot in lbs. and ozs.	249–8	81–3	74–2	52–3	117–9	140–2	185–4	168–0	93–1	116–9	209–5	264–7
Rate of yield, in tons per acre..	4.99	1.62	1.48	1.04	2.35	2.80	3.70	3.35	1.86	2.33	4.19	5.29

Notes upon the Table:—Considering the very small yield on all the plots, no deductions would be safe did we not find the general results confirmatory of those obtained in the two years preceding. But from the above table, considered in connection with the former records, the following comments seem justified:—

1. The two plots giving greatest yield are I. and XII., for the three years, 1889, 1890 and 1891; but XII. produced more than I. this last year, for the first time.

2. As heretofore, nitrate of soda (Plot I.) gave a much larger yield than any other single element of plant food, and was second only, the past season, to the "complete fertilizer" on Plot XII.

3. In all three years, Plot VII., with a very large application of phosphoric acid, did better than Plot VI., which received only half as much phosphoric acid, and nitrate of soda in addition.

4. The plots IV. and IX., both of which have received no fertilizer during the three years' tests, are among those having the poorest yields. Plot IV. gave the lowest yield in 1889 and in 1891, and next to the lowest in 1890.

5. Plots III. and IX. have equal quantities of phosphoric acid, and the latter has potash also. This addition of potash appears to have increased the crop nearly fifty per cent. in 1890, and to have more than doubled it in 1891.

6. The phosphoric acid on Plot VII. was double that on Plot III., and the crop was more than double.

7. Comparing the records of Plots I. and II., for three years, shows that, on this soil, nitrogen in the form of dried blood is not profitable for the tomato. Indeed, for two years, 240 lbs. of dried blood per acre has been no better than nothing,—as seen by comparing Plots II. and IX.

8. According to Plots V. and X., potash alone does as well as when nitrogen (as nitrate of soda) is added. But this is contradicted by comparing V. with VIII. And further, the excess of produce on VIII. over that on X., cannot be accounted for, especially since the latter received twice as much potash as the former.

9. The general results of this test seems to confirm the conclusions of the previous years, as follows:—

a. Nitrogen in the form of nitrate of soda, is the best single fertilizing material for tomatoes.

b. Potash, in the form of muriate, stands next in value.

c. Better results are usually obtained by a mixture of two or three fertilizing elements.

d. The tomato pays well for being fed well.

e. It is not profitable to grow the tomato on the same land, year after year.

VII.—Strawberry Work of the Season.

The strawberry work for the season of 1891, of this Station, has been published in Bulletin No. 13. It comprised a rather extended set of observations and tests that need be only summarized in this report. The season was a favorable one, and we believe the results are reliable.

1. There were 118 varieties in fruit the past season and included in the variety tests.

2. The six varieties producing the greatest number of berries in matted rows, named in the order of productiveness, were,—Staymen's No. 1, Sadie, Staymen's No. 2, Cloud, Crescent, Thompson's No. 7. All these are pistilates.

3. The six varieties producing the greatest weight of berries for the season, were as follows:—Staymen's No. 1, Sadie, Warfield, Mrs. Cleveland, Clingto, Staymen's No. 2. Other varieties that followed closely were,—Thompson's No. 7, Van Deman, Crescent, Cloud and Eureka. These are all pistilates, except Cling to and Van Deman.

4. The yield of six greatest producers, by weight, made crops at the following rate per acre in quarts:—

Staymen's No. 1	15,593	Mrs. Cleveland	11,968
Sadie	12,484	Clingto	10,946
Warfield	12,044	Staymen's No. 2	10,482

5. The six giving the Largest Average Berry, by weight, were,—Tippecanoe, Ontario, Jessie, Viola, Gandy and Logan. Of these only the Gandy was found among the thirty highest in yield, the rest were light producers. Of those that were among the best producers, the Van Deman had the largest average berry.

6. The varieties that had the Strongest Stamens and also produced over 4,000 quarts per acre, were,—Cling-to, Cumberland, Iron Clad, Porter's Seedling, Michael's Early, Lovett's Ea., Mammoth and Bidwell. There are other bisexual varieties that produce more than these (except Cling-to), but have much weaker stamens.

7. As a rule, those varieties that have a short fruiting season are light producers. But some of the poor producers have a long fruiting season. The ten best yields had an average fruiting period of 23 days.

8. The Earliest Variety was Michael's Early, which also gave a good yield of 4,690 quarts per acre. This variety has an excellent flavor. The second in earliness was Hoffman, but it did not give a heavy yield. The third in earliness, and one of the best producers, was the Van Deman, its crop being at the rate of 9,194 quarts per acre.

9. The Latest Varieties and their yields per acre in quarts were—Staymen's No. 1, 15,593; Cling-to, 10,946; Eureka, 8,563; Cumberland, 8,330; Mt. Vernon, 8,221; Haverland, 7,980; Daisy, 6,917; Gandy, 5,592; Piper, 5,355. The last two were the latest to begin to ripen their fruit, but did not continue to bear as late as Staymen's No. 1 or Haverland, nor any later than others named in this paragraph. The Gandy averaged the largest berries, Haverland stood second,

Cumberland third, Eureka fourth, and Mt. Vernon fifth. The Gandy is probably the prettiest and most salable of the late berries.

10. The Best Medium Varieties with average yields per acre in quarts were:—Warfield, 12,044; Mrs. Cleveland, 11,968; Staymen's No. 2, 10,482; Thompson's No. 7, 9,765; Crescent, 9,134; Cloud, 9,086; Wonderful, 8,482; Shuster's Gem, 7,472; Lida, 7,329; Bessie, 7,053; Burt, 7,024; Surprise, 6,988. Of these the best growers and most salable berries were Warfield, Thompson's No. 7, Shuster's Gem, and Surprise. The last had the largest berries on an average. Bubach No. 5 comes in this group, but its yield was only 5,248 quarts. It stood second in size of berry, and is a fine variety.

11. Frost Blighted Varieties that are otherwise valuable are,—Lovett's Early, Mammoth, Sharpless, Surprise, Jessie, Loudon's No. 15, Indiana, Great Pacific, Belmont and Westbrook. The indications are that the blossoms of bisexual varieties are more easily frost blighted than pistilates.

12. In Hill Culture all the best producing varieties yielded less than in matted row. The size of berry was not uniformly in favor of hill culture. With the best varieties it was about evenly divided.

13. The Best Succession Varieties are Michael's Early, Warfield or Van Deman, and Gandy. Michael's Early to be used for pollenizer.

14. The Best Keepers or shippers, of the best producers, were,—Surprise, Thompson's No. 7, Warfield, Shuster's Gem, Gandy, Van Deman, Bessie, Cumberland, Cloud, Cling-to and Hoffman,—in the order named.

15. The Least Rusted of the best producers are,—Cling-to (9), Eureka (11), Haverland (4), Van Deman (5), Hoffman (6), and Bubach No. 5 (13). The figures indicate the average percentage of rust for two years.

VIII.—Blackberry Tests,—Notes and Observations.

This past season we picked and weighed all the fruit on the Blackberries set for variety tests. There are six vines of each variety, except as otherwise noted. The results of the pickings and some other data are found in the following table. The yield per acre was computed on the basis of 2,074 plants planted 3x7 feet; of course these figures are merely to assist in comparison, being otherwise very unreliable. These vines received good culture, were properly winter-pruned and were treated as nearly the same as could be done in gen-

eral culture. The soil was not quite even, and it may account for those from about numbers 13 to 19 bearing poor crops, except the Dewberry. The soil where these few stood was somewhat gravelly with a loamy clay, while the remainder stood on a clay-loam free from gravel. No fertilizers were used this season. All the new plants were removed in the early spring. This was the third season since setting.

TABLE V.—VARIETY TEST OF BLACKBERRIES.

Plot Number.	Varieties. (*Rubus villosus.*)	Date of First Picking.	Weight Berries in Ounces from June 19 to July 2.	Weight Berries in Ounces from July 2 to July 20.	Weight Berries in Ounces from July 20 to August 4.	Total Yield Berries in Ounces.	Weight of a Quart in Ounces.	Yield in Quarts per Acre. Rate.	Number of Plants in bearing.
1..	Agawam............	July 11.	......	$80\frac{1}{2}$	$13\frac{1}{1}$	$93\frac{9}{16}$	$22\frac{1}{4}$	1405	6
2..	Ancient Briton......	" 18.	......	$2\frac{1}{4}$	$6\frac{1}{2}$	$8\frac{3}{4}$	......	......	1
3..	Thompson's Ea. Mam.	" 6.	......	$92\frac{7}{8}$	2	$94\frac{7}{8}$	$22\frac{1}{2}$	2851	3
5..	Minnewaska	" 9.	......	$87\frac{5}{8}$	$110\frac{3}{16}$	$197\frac{13}{16}$	......	2972	6
6..	Early Harvest.......	June 19.	$135\frac{11}{16}$	$123\frac{7}{8}$	$4\frac{1}{4}$	$263\frac{13}{16}$	22	3964	6
7..	Early Cluster........	July 6.	......	$59\frac{1}{4}$	$2\frac{1}{2}$	$61\frac{3}{4}$	......	928	6
8..	Kittatinny	" 6.	......	$52\frac{1}{2}$	$9\frac{1}{2}$	62	......	1242	4
9 ..	Crystal White........	" 9.	.....	16	......	16	.....	......	6
10..	Erie................	" 6.	......	$43\frac{5}{16}$	$53\frac{1}{4}$	$96\frac{9}{16}$	......	1450	6
11..	Wilson's Early......	June 26.	$12\frac{3}{4}$	$85\frac{5}{16}$	$4\frac{1}{8}$	$102\frac{3}{16}$	24	1841	5
12..	Lawton.............	July 9.	.....	$33\frac{1}{16}$	$39\frac{3}{4}$	$72\frac{13}{16}$	......	1094	6
13..	Wilson Junior.......	" 2.	......	$79\frac{5}{16}$	$1\frac{7}{16}$	$80\frac{3}{4}$	$23\frac{1}{2}$	1213	6
14..	Snyder..............	" 9.	......	$36\frac{3}{16}$	$2\frac{14}{16}$	$39\frac{1}{16}$	......	587	6
15..	Early King..........	June 26.	$28\frac{1}{2}$	$9\frac{7}{8}$	......	$37\frac{15}{16}$	.....	568	6
16..	Taylor's Prolific......	July 16.	......	$2\frac{3}{4}$	$5\frac{5}{8}$	$8\frac{3}{8}$	......	.....	4
17.	Wachusett..........	" 9.	......	$66\frac{13}{16}$	......	$66\frac{13}{16}$	......	1008	6
18..	Child's Everbearing..	" 6.	......	$2\frac{9}{16}$	$3\frac{3}{8}$	$5\frac{15}{16}$	......	.....	2
	Rubus canadensis.								
19..	Lucretia Dewberry...	June 26.	$40\frac{5}{16}$	$22\frac{1}{4}$	$11\frac{3}{8}$	$73\frac{15}{16}$	......	2220	3

NOTES AND OBSERVATIONS ON BLACKBERRIES.

1. *Agawam.*—A nice thrifty plant. Rather erect growth, large, fine palmately divided leaf; tips of branches droop. Badly rusted. Of medium productiveness. Berry, large to medium. Produces scattering new plants. Not the best for profit.

2. *Ancient Briton.*—A strong vigorous vine. Produces very few new plants. Large pubescent fine palmately divided leaves, drooping branches. Not prolific enough. Rusts badly. But only one plant to judge from.

3. *Thompson's Early Mammoth.*—Almost rust-proof, but had considerable leaf-spot or blight disease (Septoria rubi). Leaves smallish, three-foliate. Growth quite erect, an occasional drooping branch. Had quite a number of "double" blossoms. A good variety. One of our best producers.

5. *Minnewaska.*—This fine berry originated with A. J. Caywood, at Marlboro, N. Y., in 1883. It was produced by fertilizing Kittatinny with wild pollen. The latest berry tested, and as shown in above table, the most prolific from July 20 to August 4. It stood second in prolificacy. It had a few "double" flowers, but these were confined to the latest blossoms. Some rust and leaf blight, but neither bad. Berry very large, and holds up well in size through the season. Of best quality. Vines inclined to lop over, spreading. Leaves on fruiting stems, as in most other varieties, affected some by red spider (Tetranychus telarius, L.). Vigorous plant. Forms a fair amount of young plants. One of the best varieties tested. The best late variety. It is not the same as *Erie*, as claimed by some, although its growth is similar to it.

6. *Early Harvest.*—The best early variety. The most prolific of all varieties tested. Berry elongated and comparatively small,—not of best quality. Growth quite upright. Leaves medium sized, 3 to 5 foliate, no rust or blight this season. Very little rust last year. Very vigorous, and throws out an abundance of young plants. A fine plant in every way. No "*double*" blossoms. One of the most profitable berries for general culture.

Note by the Director:—This berry resembles in shape and firmness, and somewhat in flavor, the native "high-bush blackberry" of New York and New England. The flavor is peculiar and mulberry-like; it is disliked by some, but is a great favorite in the market when it becomes known. H. E. A.

7. *Early Cluster.*—Vigor 75 per cent. Erect growth, but not as heavy as Early Harvest. Little rust. Medium narrow leaves, 3 to 5

foliate. Many illy-formed berries. No "double" blossoms. Not prolific. Has not proved valuable here.

8. *Kittatinny.*—Heavily rusted in 1890, and considerably in 1891. Next to Minnewaska in size and lateness of berry. Growth spreading. But few new plants produced. 3 to 5 foliate, leaves of medium size. A standard variety, but not to be recommended for planting on a large scale, on account of tendency to rust.

9. *Crystal White.*—A novelty of no value here. Berries deformed and small. Seems to be but partly pollenized. Plants vigorous enough, upright, and leaves and canes very light green. Leaflets narrow, 5 foliate. Slightly affected with rust. Holds leaves late in fall. Unproductive. Makes too many new plants.

10. *Erie.*—Has large broad 5 foliate leaves as Agawam, and more severely rusted; also some leaf blight. Growth spreading. Fruit smaller than Minnewaska. Vigor 85 per cent. Forms but few new plants. Not as desirable for late as Minnewaska and Agawam.

11. *Wilson's Early.*—This variety seems almost exempt from rust, but is badly attacked by *septoria rubi.* Growth spreading. Mostly 3 foliate medium leaves. A few double blossoms. Red spider did some damage to fruiting canes. A very fine Early variety. Larger berry than Early Harvest, and considered better quality by some, but not as early or prolific. Vigor 80 per cent. One plant in this row, probably not a Wilson's Early, was dug up May 8th, because it was badly rusted.

12. *Lawton* (*New Rochelle*).—A fairly productive late variety, but more acid than Minnewaska, and a smaller berry. Red spider attacked fruiting stems rather severely. Vigor 80 per cent. Not as spreading in habit of growth as Wilson's Early. A few double blossoms. Not to be recommended for this section.

13. *Wilson Junior.*—This variety has the largest and best quality berry of any we have tested. Is fairly productive. Has very little rust, but is like Wilson's Early severely attacked by *septoria rubi.* Several cases of double blossoms. Vigor 70 per cent. This is one of the best medium sorts.

14. *Snyder.*—This is a variety that differs from all other varieties in the nature and color of its leaves. They are of a dark green, and the leaflets are very large, broad and heavily pubescent. 3 to 5 foliate. Not very vigorous in growth here, about 50 per cent. as compared with others. But in rich soils it grows seven feet high. The stems are few and heavy. Rather badly rusted in 1890, but very

little this year. Slightly attacked by leaf blight. Rather erect in growth. Berry is rather acid, but in rich soil is very large. Should be tested elsewhere in the State before a final opinion is rendered.

15. *Early King.*—Only lightly rusted. 3 to 5 foliate, leaves of medium size. Vigor 65 per cent. A sweet berry of medium size. Badly rusted in 1890. Not prolific here. Not to be recommended yet.

16. *Taylor's Prolific.*—Heavily rusted this season. 5 foliate medium leaves, accummate apex, and a peculiar lead green color. Berry small and of poor quality. Somewhat spreading, slim growths. Much like Tyler. May do better on richer soil.

17. *Wachusett.*—A rather erect growing plant with 65 per cent. vigor, sharply serrated and accumminate leaflets. 5 foliate, quite red canes. But little rust in 1890 and more this year. Affected somewhat by red spider. Late and fairly productive. May do better on other soil.

18. *Lucretia* (Dewberry).—This plant has no rust, but is severely attacked by the leaf blight. It is low and almost trailing in habit of growth. Its fruit was very fine, and as large as the largest of the blackberries. Has a peculiar, mild and rather insipid taste. Quite early and productive. It is rather more difficult to harvest than blackberries, and not of as good quality. Wild dewberry plants often rust badly. Fruit turns to a reddish color after standing a while.

19. *Tyler.*—Rusts badly here. Only 50 per cent. vigor. Leaves thin, 3 to 5 foliate of medium size. Bore only three ounces of berries. Cannot be recommended as having any value till tried on other soils.

20. *Child's Everbearing.*—Small, low plants, with only 20 per cent. vigor. Berry small and worthless. Small, mostly 3 foliate leaves. No rust. Here worthless.

21. *Jewett.*—Small weak plants. 25 per cent. vigor, but some larger than Child's Everbearing. Free from rust. Some rust in 1890. No good on this soil. No fruit.

22. *Lincoln.*—Small plants, small insipid berries. Leaves small, 3 to 5 foliate. Late. No value thus far.

"*Double Blossoms.*"—This seems to be some sort of a disease that causes the stamens to turn into petals, and several small spindling growths to come out from a single bud on the canes affected. No one has yet discovered the cause of the trouble. The blossoms that double have very imperfect berries, if any. It seems to be due to some insect irritation.

Pruning and Training the Blackberry.—It is a common practice among farmers to stake blackberry canes to hold them in an upright position. This work is useless, and is often done with canes left too long. A better plan is to practice summer pinching, and the canes will remain in an upright position without staking and tying. As soon as the new canes grow to be about two and a-half feet high, the end of each should be pinched off. This stops end and long slim growths, and causes a number of laterals to grow. The canes stand upright, and when the time of winter pruning comes the ends of the laterals should be cut off, leaving only three to five buds to fruit. It may require summer pinching at three or four different times to check the growth of all the canes as fast as they reach the desired height. This work, with the removal of the old fruiting canes, comprises all that is necessary to keep blackberries in a good fruiting and convenient form. Give blackberries good culture until the middle of August or first of September, and plenty of manure. Dewberries should be tied up to stakes, as they are too low and spreading in habit.

Red Spider on Blackberries and Raspberries.—During the past season close observation has shown that the little red spider (*Tetranychus telarius, L.*) is the cause of Blackberries and Raspberries drying up on the canes. This has been attributed by writers to dry weather, hot winds, etc. It is well known that this insect thrives best in a dry atmosphere in the greenhouse, and causes its greatest damage to several trees and plants during the hot, dry weather of the summer. I have seen parts of forests of Arbor vitæ swept away by this insect almost as if by fire. It works on the underside of the leaves, destroying their functions, and they dry up and fall. The berries receiving no support also dry up. Our raspberries were more seriously affected this season than the blackberries.

I believe the loss occasioned by this minute insect can be prevented if the vines are sprayed with the kerosene emulsion, just before the fruit begins to ripen. This emulsion is fatal to every one it reaches.

The emulsion is easily made and applied. Dissolve a bar of hard soap in three gallons of hot water. Pour into it three pints of kerosene, and churn or pump back through a syringe or pump, till it becomes a white milky mixture. Then add enough water to make the kerosene one-fifteenth of the whole mixture. It will require two sprayings to rid vines of this pest. Once just after blooms have fallen and again just before the fruit begins to ripen.

XI.—Lettuce Tests.

Seventy-seven lettuce tests were successfully made during the past season, and will probably be reported upon fully in some forthcoming Bulletin. The best varieties grown for outdoor culture were as follows:—Hanson, Grand Rapids, Denver Market, Sunset, Early Curled Simpson, Cal. All Heart, Paragon and Early Curled Silesia. These have light yellowish green fringed and rugose leaves. Very pretty varieties, but they all form loose heads or masses of leaves.

Varieties with entire light yellowish green leaves with plain entire margins, and hence not as pretty but as tender and edible as the varieties named above are—Gold Nugget, All Heart, Tittson's White Star, All Year Round, Earliest Cutting, Bloomdale Butter, Deacon and Golden Standard.

Early Cabbage, Prize Head, Tomhannock, Peer of All, Bronze Curled and Chartier have dark reddish foliage that form into rather loose heads or masses. The best long season varieties are Midsummer, Longstander Bronze Head and Shotwell's Bronzehead. These three are all very dark purplish red. The Midsummer is the best. Some of the varieties that form the best heads are New York, St. Louis Market, Royal Cabbage, Silver Ball, White Summer Cabbage and Arlington Tennis Ball. The Silver Ball is rather the best. Varieties that have a dark green, disagreeable color, are more or less bitter, tough and coarse, are Imperial, Hittinger's Belmont, Largest of All, Boston Market, Buttercup, Curled India, White Self-folding, (a Cos,) New Cos, Bath Cos, White Cos, Trianon Cos and White Folding Cos. The Cos varieties are the coarsest and most worthless varieties grown. An Oak-leaved variety was tender, light yellowish green, handsome, and odd in the shape of the leaf.

Varieties that sluff off their leaves more or less during wet weather are Early White Cabbage, Large Yellow Market, Salamander, St. Louis Market, Defiance, Philadelphia Early Market, Gold Ball, New Stubborn Seeded. Most of these are otherwise very good varieties. The first list seems to me all that can be desired for culture in houses, frames or the open ground.

X.—Pea Root Rot.

In the issue of the American Farmer of May 15th, 1891, there appeared an article under the caption, "What's the Matter with the

Pea Crop?" by R. S. Cole, of Harman's, Anne Arundel county, in which he stated: "This exclamation is heard on all sides each recurring season in this far famed and once unsurpassed pea section of the trucking portion of Anne Arundel county. From some mysterious cause, seemingly as mysterious as the peach yellows or pear blight, our peas almost universally disappoint the grower just at the critical period of *making the crop.*" After some inquiry, Mr. Cole was visited the tenth of last June. By an examination it was found, as stated in the article above referred to, that "the first symptom of the disease is a *firing* of the vines, beginning at the roots of the plants and extending upwards usually about a foot, causing the vines in many cases to die before making any pods, or so checking the growth as to materially lessen the yield." In a patch of White Marrowfats just beginning to form pods, vines could be pulled up almost anywhere with badly affected roots. In the worst cases the roots were entirely rotted off. Mr. Cole stated that this variety was more severely attacked than others, and that the disease became noticeable every year about the tenth of June. On this soil, which was a deep, dark, sandy loam, he had grown peas for four successive seasons with the same trouble for the last three seasons. On new land the disease did not appear the first year. He did not believe the disease due to anything lacking in the soil, nor to dry or wet periods, but thought it something like "black shank" in the sweet potato district of the Eastern Shore. He believed it to be due to a fungus which, when "once getting a foothold upon the soil, lies in wait for the crop to be planted upon it." Specimens of the diseased vines were brought to the Station laboratory, and, upon a microscopical examination, no micelium of any fungus was found, but multitudes of bacteria were present in every examination. No accessible authorities described any disease of this nature affecting the pea.

From comparison with forms of root rot affecting many other plants, it is evident that the true cause of this disease will be found to be a bacterium or some higher fungus. I believe Mr. Cole's idea correct in every respect, and that rotation of crops should be practiced. There is not likely to be any practical means developed of combating this disease, except by rotation. *Root rots* are diseases difficult to cope with, and of which it is difficult to determine the real cause.

XI.—Winter Budding.

To propagate rapidly new and valuable varieties, I have found a method by which a whole season is gained, and at the same time as many trees can be made as there are buds.

This was accomplished with some Japan seedling pear stock. These were placed on the 8th of April, in a hotbed having six inches of sand over the heating material. Both the heat of the sun and the manure beneath caused the sap to start in the stocks, and in eight days they were ready to bud by the ordinary method. They were taken to a warm room, budded with Mikado pearbuds, and then placed back in the sand to "take." In about eight days more they had all "taken" nicely and were transferred to damp sawdust to await planting in the nursery and to prevent them from growing. A few days later they were set in the nursery. During the summer they had good culture and made an average growth of two feet. They were all vigorous and large enough to be transplanted to the orchard by fall. This method is practicable on a large scale, and it may be that a larger and more convenient incubator can be devised to start the sap enough so the bark will run, and in which to place stocks when budded to make them "take."

XII.—Acknowledgments, with Comments.

This division of the Station has received during the year 1891, sundry donations, as named below, all of which are hereby gratefully acknowledged:—

TREES, CUTTINGS, SEEDS, SPECIMENS, ETC.

From the *U. S. Department of Agriculture:*—Osier Willows, 4 kinds; 2 Fitzwater pear trees; 1 Mission pear tree, from California; 3 Wild California Plums, 1 tree each; Buds of Payne peach.

Scions of apples, viz:—Elk Horn, Garfield, Hatly, Hennepin, Hill, Hugo crab, Jackson, Morvin and Shirk.

Scions of Krull, Jargonelle, Philopena and No. 1, from Miss., also No. 1 and No. 2, from Virginia.

1 Texas Pink blackberry, from Ga.; 2 Kansas raspberry plants; Roots of dewberries from State of Washington,—Skagit Chief and Belle.

Strawberry plants, viz:—5 Australian Crimson, 1 Banquet, 6 Dallas, 6 Doctor Morain (La.), 7 Fairmount (Cal.), 6 Imperial, 12 Lehigh

(Pa.), 12 Omega (N. J.), 1 Phillips No. 1, 1 Prairie Queen (Ind.), 12 Victor Hugo.

Seeds of Prunes Americana, Prunes demissa (So. Dak.) and Ribes aurem.

150 Botanical Specimens, mostly Maryland.

From the *Texas Agricultural Experiment Station*, College Sta., Texas:—35 varieties of Plum cuttings.

From the *Hatch Agricultural Experiment Station*, Mass. Agr'l College:—Scions of 22 varieties Apples, 26 of Pears, 6 of Peaches and 12 of Plums.

From *W. L. Amos*, Fallston, Harford County, Md.:—1 Quart Morello Cherry Pits, and seed of Ky. Coffee-tree.

From *Samuel Miller*, Bluffton, Mo.:—Apple scions,—"All Summer" and "Peter Porter,"—new varieties.

From *John G. Freight*, Dayton, Ohio:—Strawberry plants, 25 each of two new varieties, No. 1 and No. 2.

From *E. H. Amoore*, Santa Cruz, Cal.:—3 Oousliin orange trees. Two left out of doors already killed.

SPRAYING UTENSILS:—

From *Rumsey & Co., Seneca Falls, N. Y.* A spraying pump. This pump we tested fully, and found it to be very satisfactory. It is strong and well made, with a handle long enough so that much force can be appled to the liquid with ease. It resembles the one shown in Fig. 6. It is valuable for heavy tree work, and with it a very cheap and durable outfit can be arranged.

P. C. Lewis, Catskill, N. Y. For one Lewis Combination Force Pump for spraying and other work. This outfit is quite good for its price, but for spraying fungicides it does not throw a steady stream nor in as fine a spray as it should be. It makes a good garden syringe or farm syringe for animals, and in these two forms we found more use for it than for the spraying combination.

We like the idea of the combination by which so many results can be reached with but a slight alteration of the same instrument.

If an air chamber could be attached to the pump part so that a steady stream could be maintained and a Vermorel nozzle be used in place of the one devised for the outfit, it would be far more efficient.

T. L. B.

Note by the Director.

Among other horticultural work which has received attention during the year may be named, Root Pruning Experiments, Deep and Shallow Setting of Trees, Observations upon the Behavior of Georgia Grown trees when planted in this Latitude, the Best Distance Apart for planting Watermelons, and an Apple Keeping Test. But as all these now embrace the record of only one season, it is thought best to withhold publication until further data can be obtained. Good progress has been made in the study of root-pruning, and there will soon be material enough in hand for a bulletin on this subject.

H. E. A.

Meteorological Record,—1891.

Comparative Table of Monthly Rainfall.

Month.	College.		Baltimore.			Cumberland.			Washington, D. C.		
	Amount. 1891.	Rainy Days.	Normal.*	Amount. 1891.	Rainy Days.	Normal.*	Amount. 1891.	Rainy Days.	Normal.*	Amount. 1891.	Rainy Days.
	In.	No.	In.	In.	No.	In.	In.	No.	In.	In.	No.
January	5.21	10	3.20	4.89	13	2.32	2.93	7	3.36	6.14	13
February	4.66	13	3.54	5.52	16	2.43	3.99	8	3.31	4.49	15
March	7.94	15	4.09	7.94	18	2.79	7.47	16	4.20	8.84	15
April	2.66	8	3.27	2.48	10	2.22	2.02	3	3.16	2.94	8
May	4.52	14	3.55	3.11	14	3.37	2.57	7	3.90	3.72	13
June	4.01	11	4.09	5.45	11	3.43	7.69	12	4.29	4.61	11
July	8.95	16	4.94	7.79	14	3.54	5.17	12	4.65	8.40	16
August	3.22	16	4.48	4.24	13	3.27	3.44	8	4.44	4.18	16
September	2.58	6	3.84	5.46	5	2.91	2.46	5	3.98	3.12	5
October	2.47	5	3.09	2.76	9	2.21	2.39	7	3.27	2.24	10
November	1.47	6	3.15	1.33	11	2.26	2.70	3	2.91	1.47	8
December	2.86	8	3.10	3.24	9	2.28	3.42	8	2.97	2.80	8
Annual	50.55	128	44.34	54.21	143	33.19	46.25	96	44.44	52.54	138

*Made up to the end of 1890.

Meteorological Record, 1891.

Comparative Table of Monthly Temperatures.

In Degrees Farenheit.

Month.	College.	Baltimore.		Cumberland.		Washington, D. C.	
	Mean, 1891.	Normal.*	Mean, 1891.	Normal.*	Mean, 1891.	Normal.*	Mean, 1891.
January	36.32	34.3	37.6	31.2	33.2	32.6	37.4
February	41.44	37.0	41.4	33.0	38.0	36.1	41.4
March	39.28	42.1	38.6	38.1	35.9	41.4	38.6
April	55.54	53.1	56.0	51.0	54.2	52.8	55.4
May	61.09	63.9	62.2	62.0	60.9	63.6	61.4
June	70.50	72.3	71.5	69.7	70.1	71.5	71.6
July	70.41	78.6	71.6	73.7	68.7	77.6	72.0
August	72.01	74.5	74.3	71.1	70.5	73.5	74.5
September	65.11	68 2	70.6	63.9	67.1	67.4	70.3
October	55.25	58.0	54.8	53.3	56.1	57.3	54.4
November	42.17	47.1	44.2	41.3	45.6	46.4	44.0
December	42.66	38.5	43.7	33.5	39.6	37.8	43.2
Annual	54.31	53.1	55.6	51.8	53.35	54.8	55.3

*Made up to the end of 1890.

Meteorological Record,—1891.

Monthly Summary of Mean Temperatures.

In Degrees Farenheit.

Month.	Daily Mean.	Mean Daily Maximum.	Mean Daily Minimum.	Mean Daily Range.	Extreme Maximum. Date and Record.	Extreme Minimum. Date and Record.
January	36.32	45.05	29.09	15.96	27th—58.5	2nd—15.5
February	41.44	49.40	34.98	14.42	17th—72.	5th—13.
March	39.28	45.80	32.22	13.58	30th—60.5	17th—16.5
April	55.54	65.90	43.71	22.19	30th—84.5	8th—26.
May	61.09	70.72	50.51	20.21	11th—89.	6th—35.5
June	70.50	81.30	59.30	22.00	17th—93.5	9th—42.5
July	70.41	82.87	62.16	20.81	15th—86.5	12th—53.5
August	72 01	82.64	64.98	17.66	10th—94.5	1-29-30th—55.5
September	65.11	81.10	57.36	23.74	18th—91.5	10th—45.
October	55.25	65.00	44.01	20.99	3rd—86.5	29th—25.5
November	42.17	54.60	32 98	21.62	10th—68.5	19th—16.
December	42.66	55.98	32.23	23.75	24th—65.	19th—15.5
Yearly means	54.31	65.03	45.29	19.74	Aug. 10th—94.5	Feb. 5th—13.

Meteorological Record, 1891.

Precipitation in Inches, (Rain and Melted Snow.)

Date.	January.		February.		March.		April.	May.
	Total Precipitation.	Snow. In.	Total Precipitation.	Snow. In.	Total Precipitation.	Snow. In.	Total Precipitation.	Total Precipitation.
1	.07							
2							.49	
3			.31		.34	3.50	.05	.72
4					.24		*	
5								
6			*		.20	2.00		
7			.56					
8					.28			
9			.74		.16			
10	.01	.10						
11	.80						1.05	
12	.43		*		1.32		.55	.23
13			.27					
14								
15								.31
16			.67					.09
17	.52		01					
18	.01							
19					*		.44	
20			.17		.53			
21			.49		*			.04
22	1.33		.75		1.62			
23					.11		*	.14
24					.01		.08	.01
25	1.51		.18					.01
26			.51					.90
27					.90	5.00		
28					1.01			2.00
29	.08							
30								.03
31	.45				.97			.04
Totals	5.21	.10	4.66		7.94	10.50	2.66	4.52
No. rainy days.	10		13		15		8	14

METEOROLOGICAL RECORD,—1891.

Precipitation in Inches, (Rain and Melted Snow.)

DATE.	JUNE. Total Precipitation.	JULY. Total Precipitation.	AUGUST. Total Precipitation.	SEPT'R. Total Precipitation.	OCTOB'R. Total Precipitation.	NOV'ER. Total Precipitation.	DECEMBER. Total Precipitation.	DECEMBER. Snow.
1		.41						
2		1.85	*	.12				
3			.00					
4	.04	.03	.05	.03			.37	
5	.53	.01	.04	1.98		.20		
6	*		*					
7	.44	.01			.37		.94	
8		1.54		.02				
9		.04						
10								
11						.42		
12	.05							
13			.63		.50			
14				.04				
15		1.11						
16		.10				.27	.05	
17								
18	.44	1.28	.01					
19	1.14		.09		.75			
20	.21	.04	*					
21	1.11							
22	.04		.43		.76			
23		.01				.37	.03	
24			.53				.95	
25		1.49	1.01				.07	
26	.01		*				.15	
27			.02		.09	.21		
28		.58						
29		.45	.05	.39		*	.30	
30		*	.36			*		
31								
Totals	4.01	8.95	3.22	2.58	2.47	1.47	2.86	....
No. rainy days	11	16	16	6	5	6	8	....

SUMMARY OF STATION WORK,

For the Year 1891.

Physicist's Report, pages 249 to 296.

Soil Investigations—Introduction, p. 249: Argument, p. 250.

A preliminary and condensed report; much data omitted.

Importance of study of physical structure of soil and its relation to the movement of water in the soil.

Summary of Results—pp. 252–3

Circulation of Soil Water—Gravity and surface tension, p. 254

Manures and fertilizers change surface tension and modify the movement of soil water. Table I., at p. 256

Effect of Fertilizers on Texture of Soil—Phenomenon of Flocculation, p. 258.

Lime and salt cause flocculation; ammonia, etc., prevent it.

Lime—Its action on different soils explained, p. 259.

Volume of Empty Space in Soils—35 to 65 per ct., average about 50 per ct., p. 260.

Relation of Geology to Agriculture—Rocks and Soils of Maryland, p. 261.

Geological names necessary for different soil formations.

Soil Types—Determining these types for standards of comparison, a prime necessity, p. 264.

Description and location of soils and subsoils composing types, pp. 267–76.

Mechanical Analysis of Type Soils—Table 4, at p. 277: also Table 10, at p. 290.

Number of Grains in a Gram of Soil—Tables 5 and 6, pp. 278–9, show very remarkable differences in physical structure of typical soils.

See also Table 11, at p. 291.

Surface Area per Cubic Foot of Soil—Tables 7 and 8, at p. 281.

The square feet of surface of the particles in a cubic foot of subsoil, ranges from 24,000 for coarse pine barrens to 158,000 (almost 4 acres!) in fine limestone subsoil. See also p. 294.

Circulation of Water in the Type Soils—See pp. 283-85; also 295-96.

Comparisons of space, water-content and relative movement in stated soils.

Improvement of Soils—A new and wide field for investigation opened, in the study of the physical conditions of soils in their relation to plant growth and the effects thereon of fertilizers and manures.

Chemist's Report, pages 297 to 346.

Work of the Year—384 samples and over 2500 determinations.

Marls—Descriptions of samples, and classification, pp. 298-302.

Table, Composition of Maryland Marls, p. 303.

Lime and Limestones—Classification and descriptions, pp. 304-307.

Muck—Deposit of fine quality, St. Mary's Co., analysis, p. 308.

Feeding or Digestion Experiments—Silage and Stover compared, p. 309.

Details and Tabular Record of this work, pp. 310-330.

See especially Summary of Three Digestion Periods, Table XX, p. 328.

Corn Silage slightly more digestible than Corn Stover, p. 329.

Silage increases digestibility of all food compounds save protein, p. 330.

Most digestible ration tried:—corn fodder, gluten meal and wheat bran.

Effects of Acids of Silage—Upon assimilation of digested food, p. 331.

These acids appear to hinder flesh formation, p. 334.

Laboratory Studies, in same experiments—pp. 336, 341 and 344.

Artificial Digestion—Described and discussed, pp. 33?-40.

Manurial Constituents of Excreta—As examined in these trials.

Over 57 per ct. of total nitrogen voided is in the urine, p. 341.

Practical Points deducted from these Feeding Experiments—p. 346.

Agriculturist's Report, pages 347 to 378.

Silos—Points in construction and durability, p. 348.

Silage—Another year's record of storing and use, pp. 349-50.

Growing Fodder Corn for Silage—Trials described, pp. 351-52.

Results favor rows 2½ ft. apart, thin in rows, very shallow culture and mature plants.

Corn—Soil Test with Fertilizers and Corn, pp. 355–6.

23 Plots; 20 different fertilizers or combinations.

Results: generally unsatisfactory; lime and potash effective, p. 357.

Trial for Grain Increase by Removing Tassels, p. 358.

Result: seven cases out of nine unfavorable; undisturbed rows the best.

Oats—Variety test, with 42 varieties; crop and test failed, p. 359.

Notes on this trial, p. 360; and Synonyms noted. p. 361.

Wheat—Variety test, nearly 100 plots; see Bulletin No. 14, Sept., 1891.

Forage Garden—Report of progress, grasses and clovers, pp. 362-4.

The Unknown Pea, very favorably reported upon, p. 365.

Japan Clover, useful, as heretofore, with limitations, p. 365.

Rotation—The Record for 1891; no special results, pp. 366–7.

But the "lasting effects" of stable manure noted, p. 368.

Potato Experiments—Repetition of previous trials, for verification, p. 369.

Former conclusions affirmed; see Table V., p. 371.

Illustrations of the Potato work, pp. 372–3.

Results re-stated, as in Report for 1890; see p. 374.

Northern-grown Potatoes the Best for Planting—See Table VI., p. 375.

Average seven varieties; Vermont seed produced double the Maryland-grown.

Maryland seed tubers produce more unmerchantable tubers than Vermont seed.

Miscellaneous—Short reports on Sugar Beets and Flax, unfavorable, p. 376.

Feeding experiments with pigs; see Bulletin No. 12, March, 1891.

Preservation of Fence Posts—Record of trial begun, p. 378.

Horticulturist's Report, pages 379–424.

Orchard Work—Renovating treatment, p. 379; Test Orchards, p 380.

Spraying Experiments—Purposes explained, and difficulties, p. 381.

Spraying Apples; Description and results, with Table, pp. 382–3.

For this season, insecticides much more useful than fungicides.

Mixtures described:

a. Ammoniacal Copper Carbonate, with Paris Green, p. 384.

b. Carbonate Copper and Carb. Ammonia, with Paris Green, p. 385.

Spraying Experiments—*Continued.*

c. Kerosene Emulsion, Copper Carb. and Paris Green Mixture, p. 386.

d. Improved Ammoniacal Copper Carbonate, p. 386.

Miscellaneous Spraying, described, and **Bordeaux Mixture,** p. 387.

Spraying Tomatoes, did not prevent fungus disease of leaves, p. 388.

Spraying Strawberries, very beneficial; arrested leaf rust, p. 389.

Spraying Blackberries, but a partial remedy for red rust, p. 389.

Spraying Quinces, efficient to prevent leaf blight, p. 390.

Apparatus for Spraying—Appliances described and discussed, pp. 391–4.

Good Implements **Illustrated** at pp. 395–399.

Tomatoes—Variety Test of 1891; 84 varieties, p. 400.

Highest in rank, based on quality and value for market or canning, Ignotum, Brandywine, Favorite, Paragon, Volunteer and Fulton Market. Commended, Livingston's Stone.

Table of Comparison, product, 3 to 21 tons per acre, pp. 402–5.

Largest Producers: Brandywine, May Flower, Long Keeper, Fulton Market, Golden Sunrise, Table Queen, Annie Dine, Stone, Puritan, Hundred Days,—average yield of these ten, 19 tons, or 633 bus., per acre; see p. 406.

Earliest Producers:—Ex. Ear. Advance, Ex. Ea. Jersey, Hundred Days.

Potted Tomato Plants versus Transplanted—83 sets compared, p. 408.

Results strikingly in favor of the pot-grown plants.

Averages, 15 varieties, rate per acre:—potted, 18 tons; transplanted, 14½ tons.

Landreth's Beauty, potted, produced at rate of 858 bus. per acre.

Fertilizer Test with Tomatoes—3rd year, 12 plots, pp. 410–11.

Results in Table IV., p. 411; crop a failure.

Nitrogen, as nitrate soda, and potash, give best results, p. 412.

Strawberries—Reference to record in Bulletin No. 13, June, 1891.

Season of '91, had 118 varieties in fruit; results re-stated, pp. 413–14.

Blackberries—Variety Test, 19 varieties; see Table V., p. 415.

Notes on varieties, descriptions, etc., pp. 416–18.

Pruning and training; injury by red spider, p. 419.

Lettuce Tests—Brief notes on best varieties, p. 420.

Pea Root Rot—Description and advice, p. 421.

Winter Budding—A new method of rapid propagation, p. 422.

Acknowledgments—Trees, cuttings, seeds, &c., donated to Station, p. 423.

Director's Report, pages 235-247.

NOTE:—Besides references to many of the subjects named above, this Report mentions the following:

The Season—Its peculiarities, and Weather Summary, p. 236.

Co-operation—Too little; more would be judicious and economical.

Scientific Expedition to Southern Maryland—Described, pp. 237–8.

Johns Hopkins University—Renders material aid to Station work, p. 338.

Tobacco Experiments—The work of 1891 described, p. 241.

- **a.** Varieties; nothing yet found superior to native sorts.
- **b.** Field trials; experimental acres in five (5) counties, p. 242
- **c.** Curing; brief statement of work done, p. 242.

Dairy Work—Mentioned, but detailed report postponed, p. 244.

Station Improvements and Needs—Described, p. 245.

Exhibitions and Meetings—In 15 different counties, during 1891.

Visitors and Correspondence, Publications—List for year, p. 246.

Station Staff—Appointment of Physicist, p. 247.

Treasurer's Annual Report, p. 248.

Meteorological Records, 1891.

Tables—a. Comparative Monthly Rainfall, p. 425.

- **b.** Comparative Monthly Temperatures, p. 426.
- **c.** Monthly Summary of Mean Temperatures, p. 427.
- **d.** Rainfall (and Snow), Daily, for 12 months, p. 429.

Summary of Station Work, pp. 430–35.